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WARBLE FLIES.

A FURTHER CONTRIBUTION ON THE BIOLOGY OF *HYPODERMA LINEATUM* AND *HYPODERMA BOVIS*.

BY SEYMOUR HADWEN, D.V.SCI.

Veterinary Research Laboratory, Agassiz, B.C.

(With Plates XXIV and XXV.)

THE experiments here recorded were carried out in the year 1913 and the spring of 1914; they were performed with larvae taken from the gullets of steers. Some observations were subsequently made on the habits of the adult flies and the process of oviposition. The protocols of two experiments are given first, and the explanation of these follows.

Two Experiments with Larvae taken from the Oesophagus.

Calf A. The calf used for this experiment was born on Sept. 28th, thus excluding the chance of its having been attacked by warble flies. On Dec. 1st, twelve larvae were extracted from the gullets of two steers. These were removed carefully so as to avoid injury. As each was extracted it was placed between two folds of gullet and kept in a warm place. The removal of the larvae took about half an hour. An incision was made in the right hind-quarter of the calf and the larvae were dropped one by one into this pocket. The wound healed rapidly and no traces of the larvae were seen until February 2nd, when four warbles were discovered on the animal's back. All except one were on the right side. Two of these became absorbed later, and two remained till after March 10th, when they also became absorbed.

Calf B. On January 25th, 26 second-stage larvae were secured as in the preceding experiment from four gullets. They were placed in a pocket on the left hind-quarter of a November calf. On February 2nd, several warbles could be felt on this animal's back. One of them was

squeezed out of the skin by way of control. Later eleven of them pierced the skin all along the left side of the back. However, these died subsequently, one by one, and were absorbed. On March 10th only the punctures which they had made were visible, and all swelling had subsided. (Plate XXIV, Figs. 1 and 2.)

The main object of these experiments was to determine if the second-stage larva, taken from the oesophagus and thus interrupted in its life-cycle, was capable of completing it in another animal. In Koorevaar's experiments (cited by Carpenter), the larvae were introduced beneath the skin of dogs and rabbits, and they were found 14 days later in various parts of the body, including the spinal canal and the walls of the gullet. Koorevaar therefore concluded that the maggots only reach the gullet, or spinal canal, after extensive wanderings through the tissues of the ox or calf, and that they do not travel to the gullet by way of the mouth. This hypothesis appears to me to be the most likely, and the experiment with Calf A given above appears to support it. In this experiment the larvae were not seen for a period of eight weeks, four of them were then noticed on the calf's back; and it is certain that they were, during this period, in some unknown part of the animal, possibly in the gullet (?).

In the case of Calf B the larvae were introduced into the calf, and their life-cycle interrupted, at a later stage, and it may be that they were too far advanced in their development to return to the gullet, and not sufficiently matured to migrate to the back. For this reason they did not develop fully. It was noticeable that in Calf A two of the warbles were larger, and it looked for a time as if they would reach maturity.

In a recent article by Carpenter and Hewitt the authors quote Gläser (1913), who states that the newly-hatched larvae he had under observation died in one and a half hours if left in dry air, but that within an hour after hatching they could be revived by transference to water, in which they would live for two days. He concludes therefore that they need moisture for their further development and that they would obtain this in the gullet. Newly-hatched larvae, placed by him on the shaved skin of an experimental calf, made no attempt to bore through. One young maggot, however, hatched from an egg laid on his trousers by a female *H. lineatum*, in June, bored through the skin of his own leg and disappeared in one and three-quarter hours, leaving a small round red spot visible externally. Four or five days later the larva could be felt through the skin, having grown to a length of 2·5 mm. Then it

Fig. 1. Calf B, showing punctures made by warble larvae

Fig. 2. Calf B, showing several warbles upon the back

apparently worked its way upwards, for early in September swellings were apparent on the hip and abdomen, and at the end of that month a swelling at the lower end of the gullet was indicated by pain when swallowing. This moved quickly up the gullet and on October 2nd Gläser had the satisfaction of extracting a warble maggot, 7·5 mm. long, from his own mouth.

"This involuntary experiment tends to show that a warble larva can bore through the skin of the leg and work its way into the gullet in the human subject, and that the insect might pursue the same course in the ox. As mentioned in the introduction to this paper, the experiments with muzzled calves tried during several years at Ballyhaise, show that animals apparently unable to swallow either the eggs or the young larvae of *Hypoderma* are at the most but partially protected from infection. The strong mouth-hooks and piercer and the well developed spiny armature of the newly-hatched maggot suggest that it could, perhaps, bore as readily through the skin as through the mucous coat of the gullet, and we may after all find the former to be the usual mode of entrance."

The quotation just given supports my belief that the newly-hatched larvae penetrate the unbroken skin. I have already shown that the egg is laid on the legs of the animal and is attached to the base of a hair, next the skin. This has been confirmed by Professor Carpenter. The parts where the eggs are laid are not easy of access to a cow's tongue and the hair covers the egg completely. Gläser mentions the fact that moisture is necessary to keep the larvae alive; there are many opportunities for a cow to wet her legs during a summer day, through the dew in the morning or when drinking; and the skin and hair would remain moist for a considerable period. In experiments by Gläser the larvae were placed upon an area of shaven skin, but, in Carpenter's abstract of his paper, no mention is made about supplying moisture. In any case, an experiment such as Gläser describes places the parasites in somewhat abnormal surroundings. The experiments which I shall presently describe are also open to criticism, since the larvae had been hatched some hours before they were put on the calf, and their vitality may have been impaired.

Several reasons suggest themselves as to why the larvae select the gullet in which to pass certain stages of their existence. The areolar tissue is only slightly vascular and the reaction on the part of the animal against the parasites is inconsiderable. In other organs or tissues examples of encysted parasites are frequently seen, but I have not yet

found an encysted warble larva in the gullet. One reason for this may be that the larvae are constantly moving, and this may also account for their ability to pass through other tissues on their final journey to the back. It is noteworthy that nearly all the Helminths select either the abdominal cavity and respiratory tract or the skin for their habitat; for instance, *Gongylonema scutatum* is found in the walls of the gullet, Strongyles in the lungs, bots in the stomach, etc. Possibly the presence of a freer supply of oxygen than could be obtained in the deep tissues, may lead them to select these situations, though the food supply may also be an important factor in their choice.

The final position taken by the larvae is in fibrous tissue, of somewhat the same nature as that found in the gullet. The reaction of the body against them is manifested by oedematous swellings. Very probably this reaction would end in their destruction, since they have now taken up a fixed position. But shortly after reaching the back they bore through the skin, and bacteria gain entrance to the cavity in which they lie. Hence it would seem that the presence of these bacteria helps the larvae in maintaining their position, as the tissues have now two foes to cope with instead of one. In summing up, I think the reader will agree that the above experiment supports the view that the larvae gain entrance to the body by penetrating the unbroken skin. This view awaits confirmation and I am recording these observations merely for the purpose of adding my quota to the evidence already gathered.

The next point of interest concerns the position taken up by the larvae under the hide. While studying the structure of warbles I have noticed that the opening through the hide is oblique, and that the larva lies with its ventral surface upward. The caudal end is bent and protrudes through the opening, and this gives one the impression, from an outside view, that it is placed perpendicularly beneath the hide instead of horizontally, as is actually the case (Plate XXV, Figs. 3 and 4). Perhaps this has already been noticed by other observers, but I have seen no record of it. The point I wish to make is that, in the horizontal position, the effect of the skin movements is reduced to a minimum. Probably for a somewhat similar reason the second-stage larvae lie longitudinally in the oesophagus. The contraction of the longitudinal muscles would simply cause the larva to shorten its body as it does naturally. If it lay transversely, the circular muscles would bend the body sideways.

Fig. 3. The under side of a cow's hide showing (on the right) a partial dissection which reveals a young larva lying horizontally and (on the left) an unopened warble

Fig. 4. The same specimen shown in fig. 3, the warble on the left having, however, been partially dissected so as to reveal the position of the larva

The time taken for the emergence of Hypoderma lineatum from the pupa.

4 larvae found in a stable on 20. III. 13, all emerged before 16 days.

3 larvae squeezed out 21. III. 13, emerged before 14 days.

5 larvae squeezed out 21. III. 13, all emerged before 19 days.

1 larva found in a stable on day of emergence, 22. III. 13, hatched in 13 days.

These larvae were kept in an incubator with intermittent heat up to 32° C. This shows how the temperature will influence the early or late appearance of warble flies in the spring. A large number of larvae were secured during the spring of 1913 ; nearly all were of *H. lineatum*, *H. bovis* only appearing later. It was thought that in the spring of 1914 *H. lineatum* would be plentiful, but the contrary has proved to be the case ; most of the larvae secured so far are of *H. bovis*. Possibly the season may be responsible for this, as the early spring of 1913 was very wet. No specimens of *H. lineatum* were captured out of doors, but *H. bovis* was caught at a later date.

Observations made in 1914.

H. lineatum. On May 15th a calf was observed to "gad." No warble flies were seen on this date, and the other animals in the field showed no uneasiness. *Tabanus affinis* Kirby appeared on the same day.

Since no warble flies had been seen as early as this in previous years, it was thought that the calf might be extra sensitive and that the Tabanidae were responsible for his fright. However three days later, May 18th, a *H. lineatum* ♀ was captured in the following peculiar manner : the farm herdsman noticed that a bull which he had tethered outside the barn was tossing his head in a strange way ; the animal was lying down at the time. On approaching he saw a fly on its breast and killed it by slapping it with his hand. At this moment I happened to be passing, and the herdsman handed me the fly, which I perceived at once to be a *H. lineatum* ♀. He told me that the fly appeared to be stuck to the bull when he first saw it. All this time the bull remained quite quiet and displayed no uneasiness. This observation is recorded to show how little fear this fly may engender as compared to *H. bovis*.

Later in the season similar observations were made. On May 29th two specimens of *H. lineatum* were captured. On this occasion one was seen ovipositing on a cow's foot, just under the dew-claws ; a search

was made and two eggs were found side by side on a single hair. Another fly was seen resting under a cow's heel. The flies did not seem as active or as wild as *H. bovis*. There were nine head of cattle in the paddock and it was observed that only one, the young steer previously mentioned, was really terrified. The other calves ran occasionally but did not stampede. The cows paid little or no attention and sometimes hardly lifted their tails when the fly was ovipositing.

The last capture of *H. lineatum* was made on May 30th. The fly was resting on the heel of a cow which was feeding at the time. Indeed in the whole course of these observations the fly was never observed to strike above the hock. For the first time since warble flies were studied here, we have observed oviposition in *H. lineatum*, and can confirm the statement made by Gläser, that the fly fastens itself more firmly to the hairs than does *H. bovis*, and remains there for a longer time. This is of course necessary since it lays several eggs in sequence on the same hair and doubtless for the same reason it frightens the cattle less than does *H. bovis*. In my first publication I gave good reasons for the statement that *H. bovis* deposits its eggs singly, and cast some doubt upon Riley's statements about the method of oviposition in *H. lineatum*, since it showed such a great difference from what I had observed in *H. bovis*. This doubt was perhaps quite legitimate, as Riley had not himself seen the fly ovipositing, but had based his statement on the observations of an anonymous person. In any case we were both correct in what we said regarding the species we were describing. When I casually took up this work in 1912, I made the surprising discovery that Riley's finding of the eggs of *H. lineatum* (1892) was the first and only record of its kind; also that the eggs of *H. bovis*, figured in the text-books, had been obtained from flies bred in captivity; moreover, that oviposition in *H. bovis* had never been described, for the simple reason that no one had succeeded in finding the eggs attached to the hairs of cattle.

Another point which Gläser mentions, about *H. lineatum* appearing before *H. bovis*, has been confirmed by this season's work. Gläser places the period of hatching, from egg to larva, at about four days. At the laboratory here, two out of three eggs hatched in six days. These were kept in a vial with moisture, in my pocket. An experiment was tried to see if the larvae would penetrate the unbroken skin. They were placed upon a portion of shaved skin, on a calf, and kept supplied with moisture. One of them remained quiescent the whole time; the other made an apparent attempt to bore through the skin, but after

a time its movements ceased. Another attempt was made later with two larvae of *H. bovis*. These also hatched six days after the eggs were laid. The experiment was again unsuccessful; one larva, as in the preceding case, made no effort to penetrate the hide, while the other made an attempt and then was unfortunately lost. Whether it was brushed off by the calf or not, I cannot say.

Hypoderma bovis.

The first time the cattle were really seen to "gad" was on May 31st, and on this date the first capture of *H. bovis* was made. By noon all the animals were exhausted. It was suspected that *H. bovis* was the cause of the trouble, and later a single female was caught. After the fly was captured the animals remained tranquil for the rest of the day.

On June 2nd the animals were again running about the paddock terrified. A fly was captured and the animals were then shut up. A small calf, which had never been outside before, was tied to a post, and the fly was liberated near it. It struck the calf a number of times and finally the animal became so terrified that it lay down. The same thing has happened several times this season with the animals which were loose in the paddock. This paddock is small and there is no shelter provided for the cattle, so that if the flies are numerous the animals finally become so tired and stubborn that they lie down; they behave in exactly the same way as cattle which are reluctant to be driven. Once or twice I have seen *H. bovis* attack them when they were lying down. Oviposition in this case occurred on the flanks and round the buttocks. This year I have seen *H. bovis* ovipositing higher up on the host's body than I ever did before, and have secured several eggs which were laid on the rump, near the root of the tail. In 1912 no eggs were discovered above the stifle-joint.

Flies were very numerous during the month of June, and on the 10th five specimens were caught with the net during the day. A curious observation was made on this day. One of the flies which had been caught a few minutes before, was placed on a calf's back, the net being held above it to prevent its escape; it had not been on the animal for more than a minute, when it was seized with a kind of spasm and died instantaneously, the whole body becoming rigid immediately after death. This observation is recorded because another fly had died in the same manner in a previous experiment. In neither case had the insect been injured during capture. The warble fly appears to be a delicate insect which cannot stand much handling, and in this it

presents a great contrast to blood-sucking flies. I have not succeeded in keeping them alive for more than a few hours in captivity. In large cages they batter themselves to pieces in a short time, and in small cages they do not live much longer.

Summary.

The experiments with warble-fly larvae, taken in conjunction with the evidence of Carpenter and Gläser, lend support to the view that they gain an entrance through the skin.

The hypothesis is advanced that the larvae select the gullet for reasons connected with their development and growth. These may be: a freer supply of oxygen, and a loose areolar tissue which offers comparatively little resistance to them.

The position of the larva under the hide is horizontal. In this position the skin movements affect it but slightly, or less than if the position were perpendicular.

H. lineatum does not terrify cattle as does *H. bovis*, the fly was seen ovipositing and the animals showed little uneasiness during the process.

The seasonal activity of *H. lineatum* is earlier than that of *H. bovis*.

Observations were made on oviposition which confirmed those of Riley and Gläser.

Two experiments were tried with larvae, to see if they would penetrate the hide, but no definite results were obtained.

Further proof is afforded of the terror which *H. bovis* inspires in cattle. It was observed that animals, exhausted by running, occasionally lay down and became more or less indifferent to the attacks of the fly. On these occasions the eggs were laid higher up on the host's body.

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A LIST OF THE TREMATODE PARASITES OF BRITISH MARINE FISHES.

By WILLIAM NICOLL, M.A., D.Sc., M.D.

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Introduction.

In a recent paper (Nicoll, 1914) an account was given of the Trematode parasites occurring in the fishes of the English Channel, and at the same time an attempt was made to compare the records found in that locality with those in other British areas.

As mentioned in that paper I have now been fortunate enough to have had an opportunity of examining, more or less thoroughly, nearly all the species of marine fishes frequenting British waters. In addition, extensive observations on the same subject have been made on the Northumberland coast by Miss Lebour, in the Irish Sea by Johnstone and A. Scott, and at Aberdeen by T. Scott. These researches have extended over a period of 13 years and it seems advisable that some summary should be made of the results obtained. An endeavour will be made to do so as briefly as possible in the following lists.

It is somewhat doubtful if the time is yet ripe for an attempt at a complete account of the Trematode parasites of British marine fishes, that is, of essentially British fishes and not of those which are only sporadic visitors. Nearly 100 species of Trematodes have, up till the present, been recorded from British marine fishes. So far as I can judge from personal experience, the number of digenetic forms is not

likely to be materially increased except by the fortunate examination of some highly-infected fish such as a sun-fish or a sturgeon. A considerable addition to the number of monogenetic species may, however, confidently be expected. A small number of essentially British fishes may also prove to be the source of several additional digenetic records.

Hitherto the most extensive account of the Trematodes of British marine fishes is that by Miss Lebour (1908), who deals with and describes about a quarter of the known forms. Her descriptions, with few exceptions, are accurate and reliable, while her illustrations give a correct impression of the parasites portrayed.

Descriptions of the remaining species have to be sought in publications which are, unfortunately, not always readily accessible. It would be well if these scattered observations could be brought together in one publication, and it is hoped that the present paper may serve as a nucleus for such a complete and inclusive account.

I have attempted to compile a list of all the British marine fishes from which Trematodes have been recorded in this country, together with a supplementary list of the parasites which have been recorded from British fishes outside the British area, and which have not as yet been recorded from British waters. The latter list is, unfortunately, not quite complete, as several papers bearing on the subject could not be consulted. It is hoped, however, that these lists will be of value for reference to workers who may take up a more extended investigation of the subject in the future. It is evident from the last list that a certain number of gaps may yet have to be filled in the British records. The majority of the observations in that list have been made in the Mediterranean, chiefly by Rudolphi, Monticelli, Stossich, Looss and Odhner. A considerable number owe their origin to P. J. van Beneden on the Belgian coast, while Olsson and Odhner are responsible for a large number of records from northern fishes.

On comparing these two lists some interesting points are brought to light. In the first place there are eight more species of fishes tabulated in the first list than in the second. This is due to the fact that 27 species appear in the first list and not in the second, whereas only 19 appear in the second and not in the first. In the first case the explanation may be one of three: that the total quota of parasites has been found in the British area, or that the fish have not been thoroughly examined in other localities, or that the parasites of these fish do not occur outside British waters. In the second the interpretation is the reverse, namely that the fish have not been thoroughly

examined within the British area or that the parasites do not occur there. Only more extended investigations can determine which is the correct view in any particular case. It may so happen that some of the fishes in the first list are essentially British and rarely found in other localities, while on the other hand it is certain that many fishes in the second list are exceeding rarities in British waters, viz.: *Mugil capito*, *Naucrates ductor*, *Thynnus pelamys*, *Xiphias gladius*, and *Acipenser sturio*.

In the second place it is obvious that the number of parasitic records is about equal in the two lists. This circumstance has to be considered from several points of view. Firstly there is the fact that in the first list most of the records are recent and made according to modern principles of identification, while in the second many of the records date from a hundred years ago and have not been confirmed in the interval. There can be little doubt that several of the latter will be found synonymous with better known species. Many of the species recorded by van Beneden, for instance, and a number of other observers, require careful re-investigation. Secondly a few of the fishes live both in salt and in fresh water, the most outstanding examples of which are the common eel, the salmon and the sea trout. Some of the parasites of these fishes may prove to be entirely fresh-water and not marine. Thirdly it is obvious that in the case of some species of fishes the number of records in one list is greatly in excess of that in the other. This may be ascribed to:

1. The fish being common in British waters, has been exhaustively examined, or alternatively being rare, has been more exhaustively examined in other localities.

2. The intermediary hosts of the various parasites are more common in British waters, or alternatively in other localities.

As examples might be quoted the whiting (*Gadus merlangus*) which displays the most varied Trematode fauna of any British marine fish. This is due in part to its wide distribution in British waters and to the fact that it has probably been more exhaustively examined than any other species. A glance at the records is sufficient to indicate this.

The pollack (*Gadus pollachius*) also harbours a fairly varied fauna, though much inferior to that of the whiting. This is, no doubt, partly due to the fact that it has not been so frequently examined.

Besides these gadoids two of the flat-fishes show a Trematode fauna, in British waters, which is not surpassed in other localities, namely the long rough dab (*Drepanopsetta platessoides*) and the plaice

(*Pleuronectes platessa*). The latter fish, like the whiting, is one of those which have been most systematically examined.

Of the fishes in which the British records are exceptionally defective the outstanding examples are the sun-fish (*Mola*), the common eel and the sturgeon (*Acipenser sturio*). The first of these, as already noted, is exceedingly rare in British waters, while the other two can hardly be regarded as marine fishes in the true sense of the term.

Of the essentially British marine fishes in which there are obvious gaps in our records, the chief are the angler (*Lophius*), the bull-head (*Cottus scorpius*), the turbot (*Bothus maximus*), the smelt (*Osmerus eperlanus*) and the rockling (*Onos tricirratus*). In the case of the first-mentioned the records in many instances probably represent adventitious parasites. In the case of the bull-head the list is swelled by a number of apparently purely Arctic forms. With regard to the turbot, three at least of the records are extremely doubtful. The rockling displays a number of doubtful records, while the smelt shows three which require revision.

With regard to the fishes which may be most relied on to furnish Trematode parasites, an important matter for demonstration purposes, the whiting, as previously mentioned, stands preeminent. It is, unfortunately, a fish which undergoes very rapid decomposition and on that account it is perhaps less reliable than the cod and the pollack for providing *living* parasites. Next to the whiting the grey gurnard is undoubtedly the most productive of British fishes in the matter of Trematode parasites. The red gurnard (*Trigla pini* vel *cuculus*), where it can be obtained, is almost as good. The common dab (*Pleuronectes limanda*) is perhaps as reliable a host as any and its ubiquitous distribution renders it easily obtainable in most localities. Failing it the plaice (*P. platessa*) and the long rough dab (*Drepanopsetta platessoides*) are almost equally suitable. Next to these commoner fishes come the less common spotted wrasse (*Labrus berggylta*) and the angler (*Lophius piscatorius*), both of which are fertile sources of Trematode parasites in the localities in which they occur. Mention must also be made of the horse-mackerel and the conger-eel, both of which are constantly infected though not by such a great variety of parasites as the previously-mentioned fishes.

Some indication of the frequency and the number of the parasites in their various hosts might have been desirable. I have attempted this in a previous paper (1909 b), but in the present instance such records would be misleading and valueless on account of the fact that

most observers have not troubled to deal with such matters. A detailed statistical account would, however, be of interest.

Some note must be made on the subject of classification. Odhner (1911) has done more than any other recent writer to help in arranging the various groups of parasites in systematic order. Although his opinions are difficult to agree with in certain cases yet his system is followed in this paper as it is the most rational which has hitherto been offered. He has to a certain extent outdone Looss in his precision of detail, *e.g.* in his subdivision of the FELLODISTOMINAE, but on the other hand he has shown a welcome tendency to a broad inclusive view of taxonomy in his treatment of the HEMIURIDAE. As in other branches of zoology, the dividing line between species and genera is difficult to fix. The simplicity and naturalness of Looss's system were obvious and the system was at once almost universally accepted. Odhner, however, has discovered details, chiefly in regard to the excretory system and the terminal male genitalia, which he considers of extreme systematic importance and which are not by any means obvious on casual observation. With regard to the male genitalia, Odhner's views are undoubtedly sound, but it remains to be proved whether his ideas regarding the form of the excretory system are based on a firm foundation.

The references given are, as far as possible, those likely to be most readily accessible to English workers. In a large number of cases, however, only reference could be made to works which are exceedingly difficult to obtain. This applies chiefly to the work of older writers, but a number of extremely important modern monographs, *e.g.* Looss (1894) and Odhner (1905), are not by any means easy of access.

LIST OF THE TREMATODE PARASITES FOUND IN BRITISH MARINE FISHES, ARRANGED SYSTEMATICALLY.

Order **DIGENEA.**

Sub-Order **PROSOSTOMATA.**

Super-Family DISTOMATA.

	Authority.
Family ALLOCREADIIDAE	
Sub-Family Allocreadiinae	
Genus *Podocotyle*	
1. *P. atomon* (Rud.)	Odhner 1905, Lebour 1908.
2. *P. reflexa* (Crepl.)	Odhner 1905.
3. *P. syngnathi* Nicoll	Nicoll 1913 a.
4. (*P.*) *furcata* Bremser	Dujardin 1845, Monticelli 1893.
5. (*P.*) *atherinae* Nicoll	Nicoll 1914.

	Authority.
Genus *Lebouria*	
6. *L. idonea* Nicoll	Nicoll 1909 a.
7. *L. alacris* (Looss)	Nicoll 1910, Looss 1901.
8. *L. varia* Nicoll	Nicoll 1910.
9. (*L.*) *tumidula* Rud.	Odhner 1901.
Genus *Peracreadium*	
10. *P. genu* (Rud.)	Nicoll 1910, Odhner 1901.
11. *P. commune* (Olsson)	Nicoll 1910, Odhner 1901.
Genus *Cainocreadium*	
12. *C. labracis* (Dujardin)	Johnstone 1908, Odhner 1901.
Genus *Helicometra*	
13. *H. pulchella* (Rud.)	Nicoll 1910, Stossich 1902 (*Loborchis mutabilis*).
14. (*H.*) *colligata* Wallin	Wallin 1909.
Sub-Family Stephanochasminae	
Genus *Stephanochasmus*	
15. *S. pristis* (Deslongchamps)	Looss 1901.
16. *S. caducus* Looss	Looss 1901, Nicoll 1914.
17. *S. cesticillus* (Molin)	Looss 1901.
18. *S. rhombispinosus* Lebour	Lebour 1908.
19. *S. hystrix* (Dujardin)	Looss 1899, Dujardin 1845.
20. *S. baccatus* Nicoll	Nicoll 1913 b, and 1907.
21. *S. triglae* Lebour	Lebour 1908.
22. *S. sobrinus* (Levinsen)	Odhner 1905, Levinsen 1881.
Genus *Acanthopsolus*	
23. *A. oculatus* (Levinsen)	Odhner 1905, Levinsen 1881.
24. *A. lageniformis* Lebour	Lebour 1910.
Sub-Family Lepocreadiinae	
Genus *Lepidapedon* (*Lepodora*)	
25. *L. rachion* (Cobbold)	Odhner 1905, Lebour 1908.
26. *L. elongatum* (Lebour)	Lebour 1908.
Genus *Pharyngora*	
27. *P. bacillaris* (Molin)	Nicoll 1910, Lebour 1908 (*P. retractilis*).
28. *P. polonii* (Molin)	Molin 1859.
Genus *Lepidauchen*	
29. *L. stenostoma* Nicoll	Nicoll 1913 a.
Family Fellodistomidae	
Sub-Family Fellodistominae	
Genus *Fellodistomum*	
30. *F. fellis* (Olsson)	Nicoll 1909 a, Jacoby 1899.
31. *F. agnotum* Nicoll	Nicoll 1909 a, Odhner 1911 b.
Genus *Steringophorus*	
32. *S. furciger* (Olsson)	Odhner 1905, Lebour 1908.
Genus *Steringotrema*	
33. *S. cluthense* (Nicoll)	Nicoll 1909 a.
34. *S. divergens* (Rud.)	Odhner 1911 b.
35. *S. pagelli* (v. Ben.)	Odhner 1911 b, Nicoll 1914.
Genus *Rhodotrema*	
36. *R. ovacutum* (Lebour)	Lebour 1908, Odhner 1911 b.

	Authority.
Genus *Bacciger*	
37. *B. bacciger* (Rud.)	Nicoll 1914, Stossich 1889.
Sub-Family Haplocladinae	
Genus *Haplocladus*	
38. *H. typicus* Odhner	Odhner 1911 b.
39. *H. minor* Odhner	Odhner 1911 b.
Genus *Proctoeces*	
40. *P. maculatus* (Looss)	Looss 1901, Odhner 1911 b.
Genus *Tergestia*	
41. *T. laticollis* (Rud.)	Odhner 1911 b, Nicoll 1913 b.
42. *T. acanthocephala* Stossich	Odhner 1911 b.
Family ZOOGONIDAE	
Sub-Family Zoogoninae	
Genus *Zoogonus*	
43. *Z. rubellus* (Olsson)	Odhner 1911 a, Nicoll 1909 b.
Genus *Zoogonoides*	
44. *Z. viviparus* (Olsson)	Odhner 1902, Nicoll 1907.
45. *Z. subaequiporus* Odhner	Odhner 1911 a.
Genus *Zoonogenus*	
46. *Z. vividus* Nicoll	Nicoll 1912.
Genus *Diphterostomum*	
47. *D. brusinai* Stossich	Looss 1901, Odhner 1911 a.
48. *D. betencourti* (Monticelli)	Odhner 1911 a, Monticelli 1893.
Sub-Family Lecithostaphylinae	
Genus *Proctophantastes*	
49. *P. abyssorum* Odhner	Odhner 1911 a.
Genus *Lepidophyllum*	
50. *L. steenstrupi* Odhner	Odhner 1902, 1911 a.
Family MONORCHIIDAE	
Sub-Family Monorchiinae	
Genus *Monorchis*	
51. *M. monorchis* (Stossich)	Looss 1902 c.
Sub-Family Proctotreminae	
Genus *Proctotrema*	
52. *P. bacilliovatum* Odhner	Odhner 1911 a.
Genus *Lasiotocus*	
53. *L. mulli* (Stossich)	Stossich 1883, Odhner 1911 a.
Genus *Pristisomum*	
54. *P. pumex* Looss	Odhner 1911 a.
Family HAPLOPORIDAE	
Genus *Haploporus*	
55. *H. benedeni* (Stossich)	Looss 1902 b.
56. *H. lateralis* Looss	Looss 1902 b.
Genus *Saccocoelium*	
57. *S. obesum* Looss	Looss 1902 b.
58. *S. tensum* Looss	Looss 1902 b.
Genus *Dicrogaster*	
59. *D. perpusillus* Looss	Looss 1902 b.
60. *D. constrictus* Looss	Looss 1902 b.

	Authority.
Family Azygidae	
Genus *Azygia*	
61. *A. tereticollis* (Rud.)	Looss 1894, Odhner 1911 c.
Genus *Otodistomum*	
62. *O. veliporum* (Crepl.)	Odhner 1911 c, Mühlschlag 1914.
63. *O. cestoides* (v. Ben.)	Odhner 1911 c, Lebour 1908 (as *O. veliporum*).
Genus *Ptychogonimus*	
64. *P. megastomus* (Rud.)	Jacoby 1899, Jägerskiöld 1900.
Family Hemiuridae	
Sub-Family Hemiurinae	
Genus *Hemiurus*	
65. *H. communis* Odhner	Lebour 1908, Looss 1907.
66. *H. ocreatus* (Rud.)	Odhner 1905, Looss 1907 (*H. lühei*).
67. *H. levinseni* Odhner	Odhner 1905, Looss 1907.
68. *H. rugosus* Looss	Looss 1907.
69. *H. appendiculatus* (Rud.)	Looss 1907, Odhner 1905.
Genus *Aphanurus*	
70. *A. stossichi* (Monticelli)	Monticelli 1891, Looss 1907.
71. *A. virgula* Looss	Looss 1907.
Sub-Family Dinurinae	
Genus *Ectenurus*	
72. *E. lepidus* Looss	Looss 1907.
Genus *Lecithocladium*	
73. *L. excisum* (Rud.)	Looss 1907, Lühe 1901.
Sub-Family Sterrhurinae	
Genus *Sterrhurus*	
74. *S. musculus* Looss	Looss 1907.
75. *S. grandiporus* (Rud.)	Looss 1907, Molin 1859.
76. *S. fusiformis* (Lühe)	Looss 1907, Lühe 1901.
Genus *Lecithochirium*	
77. *L. rufoviride* (Rud.)	Looss 1907, Lühe 1901.
78. *L. gravidum* Looss	Looss 1907.
79. *L. conviva* Lühe	Lühe 1901.
80. *L. physcon* Lühe	Lühe 1901.
Genus *Synaptobothrium*	
81. *S. caudiporum* (Rud.)	Looss 1907, v. Linstow 1904 (*S. copulans*).
Genus *Brachyphallus*	
82. *B. crenatus* (Rud.)	Looss 1907, Odhner 1905.
Sub-Family Lecithasterinae	
Genus *Lecithaster*	
83. *L. gibbosus* (Rud.)	Looss 1907, Odhner 1905.
84. *L. confusus* Odhner	Odhner 1905, Looss 1907.
Genus *Lecithophyllum*	
85. *L. botryophoron* (Olss.)	Odhner 1905, Linton 1905.
Genus *Aponurus*	
86. *A. laguncula* Looss	Looss 1907.

	Authority.
Sub-Family Syncoeliinae	
Genus *Derogenes*	
87. *D. varicus* (O. F. Müller)	Odhner 1905, Johnstone 1907.
88. *D. plenus* Stafford	Stafford 1904, 1905.
Genus *Hemipera*	
89. *H. ovocaudata* Nicoll	Nicoll 1913 a.
Genus *Derogenoides*	
90. *D. ovacutus* Nicoll	Nicoll 1913 a.
Genus *Genarches* (=*Progonus*)	
91. *G. mülleri* (Levinsen)	Odhner 1905, Levinsen 1881.
Genus *Liocerca*	
92. *L. bonnieri* (Monticelli)	Looss 1899, Monticelli 1893.
Genus *Pronopyge*	
93. *P. ventricosa* (Rud.)	Looss 1899, Odhner 1911 c (Note 28).
Sub-Family Accacoeliinae	
Genus *Accacoelium*	
94. *A. contortum* (Rud.)	Monticelli 1893, Linton 1898.
95. *A. macrocotyle* (Dies.)	Monticelli 1893, Linton 1898.
96. *A. nigroflavum* (Rud.)	Monticelli 1893, Linton 1898.
Genus *Hirudinella*	
97. *H. clavata* (Menzies)	Darr 1902, Poirier 1885.
Family BUNODERIDAE	
Genus *Bunodera*	
98. *B. nodulosa* (Zeder)	Looss 1894, Lühe 1909.
Family ACANTHOCHASMIDAE	
Sub-Family Acanthochasminae	
Genus *Acanthochasmus*	
99. *A. imbutiformis* (Molin)	Looss 1901, Johnstone 1906.
100. *A. praeteritus* Looss	Looss 1901.
Sub-Family Anoiktostominae	
Genus *Cryptogonimus*	
101. (*C.*) *tubarius* Rud.	Rudolphi 1819, Odhner 1911 c (Note 18).
Family GORGODERIDAE	
Sub-Family Anaporrhutinae	
Genus *Probolitrema*	
102. *P. ricchiardi* (Lopez)	Monticelli 1893, Looss 1902.
Family DIDYMOZOIDAE	
Genus *Didymozoon*	
103. *D. scombri* Taschenberg	Taschenberg 1879.
104. *D. pretiosum* Ariola	Ariola 1902.
105. *D. tenuicolle* (Rud.)	Odhner 1907.
Genus *Didymocystis*	
106. *D. reniformis* Ariola	Ariola 1902.
Genus *Wedlia*	
107. *W. bipartita* (Wedl)	Wedl 1855, Wagener 1858.
Genus *Koellikeria*	
108. *K. filicollis* (Rud.)	v. Beneden 1861, Braun 1892.

	Authority.
Genus *Nematobothrium*	
109. *N. benedeni* Monticelli	Monticelli 1893, Maclaren 1904.
110. *N. molae* Maclaren	Maclaren 1904.
111. *N. taenioides* Monticelli	Monticelli 1888, Maclaren 1904.
UNCLASSIFIED GENERA.	
Genus *Aporocotyle*	
112. *A. simplex* Odhner	Odhner 1900.
Genus *Deropristis*	
113. *D. hispida* (Abildgaard)	Cobbold 1858, Linton 1901.
114. *D. inflata* (Molin)	Odhner 1902, Parona 1887.
Genus *Haplosplanchnus*	
115. *H. pachysomus* (Eysenhardt)	Looss 1902 c.
Genus *Leptosoma*	
116. *L. obscurum* Stafford	Stafford 1904.
Genus *Neophasis*	
117. *N. pusilla* Stafford	Stafford 1904.
Genus *Orophocotyle*	
118. (*O.*) *foliatum* Linton	Linton 1898, Looss 1902 a.
Genus *Sphaerostoma*	
119. *S. bramae* (Müller)	Looss 1894, Linton 1905.
Genus *Steganoderma*	
120. *S. formosum* Stafford	Stafford 1904.
Genus *Stenakron*	
121. *S. vetustum* Stafford	Stafford 1904.
Genus *Stenocollum*	
122. *S. fragile* (Linton)	Stafford 1904, Linton 1900.
Genus *Xenodistomum*	
123. *X. melanocystis* Stafford	Stafford 1904.
UNCLASSIFIED SPECIES.	
124. *D. anarrhichae* Rathke	Rathke 1799, Rudolphi 1819.
125. *D. anonymum* Diesing	Diesing 1858, Stossich 1886.
126. *D. aspidophori* v. Beneden	v. Beneden 1870, Braun 1892.
127. *D. calceolus* Molin	Molin 1861, Braun 1892.
128. *D. coronatum* Rentsch[1]	Rentsch 1860.
129. *D. cryptobothrium* v. Beneden	v. Beneden 1870.
130. *D. flavescens* v. Beneden	v. Beneden 1870, Stossich 1886.
131. *D. foliaceum* Molin	Molin 1859, Stossich 1886.
132. *D. fulvum* Rud.	Rudolphi 1819, Cobbold 1858.
133. *D. giardii* Stossich	Stossich 1889, 1898.
134. *D. gobii* Rentsch	Rentsch 1860.
135. *D. granulum* Rud.	Rudolphi 1809, Stossich 1886.
136. *D. homoeostomum* Diesing	Diesing 1858, Stossich 1886.
137. *D. macrobothrium* v. Beneden	v. Beneden 1870, Stossich 1886.
138. *D. macroporum* Monticelli	Monticelli 1893, 1898.
139. *D. megalocotyle* Monticelli	Monticelli 1893, v. Linstow 1903.
140. *D. microcotyle* Diesing	Diesing 1858, Stossich 1886.
141. *D. microphylla* v. Beneden	v. Beneden 1870, Braun 1889.
142. *D. microsoma* Rud.	Rudolphi 1819, Sonsino 1890.

[1] Name preoccupied by *D. coronatum* Wagener 1852.

		Authority.
143.	*D. microstomum* Rud.	Rudolphi 1809, Monticelli 1893.
144.	*D. miescheri* Zschokke	Zschokke 1890, Braun 1892.
145.	*D. minimum* v. Beneden	v. Beneden 1870, Monticelli 1891.
146.	*D. motellae* v. Beneden	v. Beneden 1870.
147.	*D. nigrescens* Olsson	Olsson 1876, Braun 1893.
148.	*D. osculatum* Looss	Looss 1901.
149.	*D. palmatum* Rentsch	Rentsch 1860.
150.	*D. polymorphum* Rud.	Rudolphi 1809, Wedl 1855.
151.	*D. rhombi* v. Beneden	v. Beneden 1870, Braun 1893.
152.	*D. soleae* Dujardin	Dujardin 1845, Monticelli 1893.
153.	*D. soleaeforme* Rud.	Rudolphi 1809, Braun 1893.
154.	*D. tobiani* Krøyer	Krøyer 1846–1853.
155.	*D. triglae* Rud.	Rudolphi 1819, Diesing 1850.
156.	*D. truttae* Moulinié	Diesing 1858, Braun 1893.
157.	*D. vitellosum* Linton	Linton 1900, 1901, 1905.

Super-Family MONOSTOMATA.

Genus *Galactosomum*

158.	*G. lacteum* Jägerskiöld	Jägerskiöld 1896, Looss 1902.

UNCLASSIFIED SPECIES.

159.	*Monostomum gracile* Rud.	Rudolphi 1809, Diesing 1850.

Super-Family HOLOSTOMATA.

Genus "*Holostomum*"

160.	*H. clavus* Molin	Molin 1858, 1861.

Genus *Tetracotyle*

161.	*T. ovata* v. Linstow (*Holostomum variegatum* larva)	v. Linstow 1877, Braun 1894.

Super-Family ASPIDOCOTYLEA.

Genus *Macraspis*

162.	*M. elegans* Olsson	Jägerskiöld 1899, Olsson 1868.

Genus *Stichocotyle*

163.	*S. nephropis* Cunningham	Cunningham 1887, Odhner 1898.

Sub-Order **GASTEROSTOMATA.**

Family BUCEPHALIDAE

Sub-Family Bucephalinae

Genus *Bucephalus*

164.	*B. minimus* (Stossich)	Stossich 1887, Nicoll 1914.
165.	*B. polymorphus* v. Baer	Molin 1859, Ziegler 1883.

Genus *Bucephalopsis*

166.	*B. gracilescens* (Rud.)	Lebour 1908, Tennent 1906.

Genus *Rhipidocotyle*

167.	*R. minimum* (Wagener)	Nicoll 1914, Wagener 1852.
168.	*R. viperae* (v. Beneden)	Nicoll 1914, v. Beneden 1870.

Sub-Family Prosorhynchinae

Genus *Prosorhynchus*

169.	*P. aculeatus* Odhner	Nicoll 1910, Odhner 1905
170.	*P. crucibulum* (Molin)	Nicoll 1910, Odhner 1905

		Authority.
171.	*P. grandis* Lebour	Lebour 1908.
172.	*P. squamatus* Odhner	Odhner 1905, Lebour 1908.
173.	*P. triglae* Nicoll	Nicoll 1914.

Unclassified Species.

174.	"*Gasterostomum*"	*clupeae* v. Ben.	v. Beneden 1870, Tennent 1906.
175.	„	*vivae* v. Ben.	v. Beneden 1870, Tennent 1906.
176.	„	sp. Johnstone	Johnstone 1905.

Order **MONOGENEA.**

Family Monocotylidae

Sub-Family Calicotylinae

Genus *Calicotyle*

177.	*C. krøyeri* Diesing	Monticelli 1892, Lebour 1908.
178.	*C. affinis* T. Scott	T. Scott 1911.

Sub-Family Anisocotylinae

Genus *Merizocotyle*

179.	*M. diaphanum* Cerfontaine	Cerfontaine 1894, 1898 b.

Sub-Family Pseudocotylinae

Genus *Pseudocotyle*

180.	*P. squatinae* v. Ben. and Hesse	v. Beneden and Hesse 1865, Taschenberg 1879 a.

Sub-Family Monocotylinae

Genus *Paracotyle*

181.	*P. caniculae* Johnstone	Johnstone 1911.

Family Tristomidae

Sub-Family Tristominae

Genus *Tristomum*

182.	*T. cephala* Risso	Risso 1826, St Remy 1898.
183.	*T. coccineum* Cuvier	Linton 1898, Diesing 1850.
184.	*T. molae* E. Blanchard	Monticelli 1891, T. Scott 1905.
185.	*T. onchidiocotyle* Setti	Setti 1899, Parona 1902.
186.	*T. papillosum* Diesing	Monticelli 1892, Diesing 1836.
187.	*T. rudolphianum* Diesing	Diesing 1850, Linton 1901.
188.	*T. uncinatum* Monticelli	Monticelli 1889, Setti 1899.

Genus *Trochopus*

189.	*T. pini* (v. Ben. and Hesse)	Massa 1906, v. Ben. and Hesse 1864.
190.	*T. tubiporus* (Diesing)	Massa 1906, Monticelli 1892.

Genus *Thaumatocotyle*

191.	*T. coninna* T. Scott	T. Scott 1904.

Genus *Heterocotyle*

192.	*H. pastinaceae* T. Scott	T. Scott 1904.

Sub-Family Ancyrocotylinae

Genus *Epibdella*

193.	*E. hippoglossi* (Müller)	Odhner 1905, Monticelli 1902.
194.	*E. soleae* (v. Ben. and Hesse)	Monticelli 1892, Odhner 1906.

Genus *Nitzschia*

195.	*N. elongata* (Nitzsch)	Monticelli 1892, v. Baer 1827.
196.	*N. papillosa* Linton	Linton 1898, Monticelli 1904.

	Authority.
Sub-Family Encotyllabinae	
Genus *Encotyllabe*	
197. *E. Nordmanni* Diesing	Monticelli 1907, Pratt 1900.
198. *E. pagelli* v. Ben. and Hesse	v. Beneden and Hesse 1864, Gamble 1896.
Sub-Family Acanthocotylinae	
Genus *Acanthocotyle*	
199. *A. verrilli* Goto	Goto 1899, Pratt 1900.
Genus *Anthocotyle*	
200. *A. merlucii* v. Ben. and Hesse	v. Beneden and Hesse 1864, T. Scott 1901.
Family UDONELLIDAE	
Sub-Family Udonellinae	
Genus *Udonella*	
201. *U. lupi* v. Ben. and Hesse	v. Beneden and Hesse 1864, Stossich 1898.
202. *U. merlucii* v. Ben. and Hesse	v. Ben. and Hesse 1864, Braun 1890.
203. *U. pollachii* v. Ben. and Hesse	v. Beneden and Hesse 1864, Gamble 1896.
204. *U. triglae* v. Ben. and Hesse	v. Beneden and Hesse 1864, Braun 1890.
Genus *Echinella*	
205. *E. hirundinis* v. Ben. and Hesse	v. Beneden and Hesse 1864, Pratt 1900.
Genus *Pteronella*	
206. *P. molvae* v. Ben. and Hesse	v. Beneden and Hesse 1864, Pratt 1900.
Family OCTOCOTYLIDAE	
Sub-Family Octocotylinae	
Genus *Octocotyle*	
207. *O. scombri* (Kuhn)	Pratt 1900, T. Scott 1901.
Genus *Octobothrium*	
208. *O. leptogaster* F. S. Leuckart	Braun 1890, T. Scott 1911.
209. *O. merlangi* (Kuhn)	v. Nordmann 1832, T. Scott 1901.
210. *O. harengi* v. Ben. and Hesse	v. Beneden and Hesse 1864, T. Scott 1901.
211. *O. pilchardi* v. Ben. and Hesse	v. Beneden and Hesse 1864, Braun 1890.
212. *O. heterocotyle* (v. Ben.)	v. Beneden 1870, v. Linstow 1885.
213. *O. sybillae* Scott	T. Scott 1909.
Genus *Pterocotyle*	
214. *P. palmata* (Leuckart)	v. Beneden and Hesse 1864, Cerfontaine 1898 a.
Genus *Discocotyle*	
215. *D. sagittata* F. S. Leuckart	Taschenberg 1879 b, Lühe 1909.
Genus *Mazocraes*	
216. *M. alosae* Hermann (*Octobothrium lanceolatum* F. S. Leuck.)	Hermann 1782, Lühe 1909, v. Beneden and Hesse 1864.
Genus *Dactycotyle*	
217. *D. morrhuae* (v. Ben. and Hesse)	T. Scott 1901, v. Beneden and Hesse 1864.
218. *D. pollachii* v. Ben. and Hesse	v. Beneden and Hesse 1864, Cerfontaine 1895, 1896.
219. *D. luscae* v. Ben. and Hesse	Cerfontaine 1898 a, v. Ben. and Hesse 1864.
220. *D. denticulata* (Olsson)	Olsson 1876, Cerfontaine 1896, 1898 a.
Genus *Platycotyle*	
221. *P. gurnardi* v. Ben. and Hesse	v. Beneden and Hesse 1864, Pratt 1900.

	Authority.
Genus *Diplozoon*	
222. *D. paradoxum* v. Nordmann	v. Beneden 1861, Zeller 1872, 1888.
Sub-Family Hexacotylinae	
Genus *Hexacotyle*	
223. *H. thynni* (Delaroche)	Linton 1901, Delaroche 1811.
Sub-Family Pleurocotylinae	
Genus *Pleurocotyle*	
224. *P. scombri* (Grube) (*Grubea cochlear* Diesing)	Pratt 1900, Taschenberg 1879 b.
Sub-Family Plectanocotylinae	
Genus *Plectanocotyle*	
225. *P. lorenzi* Monticelli	Monticelli 1899.
Genus *Phyllocotyle*	
226. *P. gurnardi* v. Beneden and Hesse	v. Beneden and Hesse 1864, T. Scott 1905.
Sub-Family Onchocotylinae	
Genus *Onchocotyle*	
227. *O. appendiculata* (Kuhn)	v. Beneden 1861, Taschenberg 1879 a.
228. *O. emarginata* Olsson	Olsson 1876, Cerfontaine 1899.
Genus *Squalonchocotyle*	
229. *S. borealis* (v. Ben.)	Cerfontaine 1899, v. Beneden 1853.
230. *S. abbreviata* (Olsson)	Olsson 1876, Cerfontaine 1899.
Family Microcotylidae	
Sub-Family Microcotylinae	
Genus *Microcotyle*	
231. *M. labracis* v. Ben. and Hesse	v. Beneden and Hesse 1864, T. Scott 1905.
232. *M. donavini* v. Ben. and Hesse	v. Beneden and Hesse 1864, Scott 1905.
233. *M. draconis* Briot	Briot 1904, Nicoll 1914.
234. *M. acanthurum* Par. and Per.	Parona and Perugia 1890, G. and W. MacCallum 1913.
Sub-Family Axininae	
Genus *Axine*	
235. *A. belones* Abildgaard	v. Beneden and Hesse 1864, T. Scott 1911.
236. *A. triglae* v. Ben. and Hesse	v. Beneden and Hesse 1864, Taschenberg 1879 b.
Genus *Gastrocotyle*	
237. *G. trachuri* v. Ben. and Hesse	v. Beneden and Hesse 1864, Pratt 1900.
Genus *Pseudaxine*	
238. *P. trachuri* Par. and Per.	Parona and Perugia 1890, Pratt 1900.
Family Gyrodactylidae	
Sub-Family Gyrodactylinae	
Genus *Gyrodactylus*	
239. *G. elegans* v. Nordmann	Wagener 1860, Kathariner 1904.
240. *G. groenlandicus* Levinsen	Levinsen 1881, Pratt 1900.
Sub-Family Diplectaninae	
Genus *Diplectanum*	
241. *D. aequans* (Wagener)	v. Beneden and Hesse 1864, Maclaren 1904.

List of Trematode Parasites recorded from British Marine Fishes in British Waters, arranged according to their Hosts.

S. St Andrews; M. Millport; A. Aberdeen; P. Plymouth; N. Northumberland (Lebour); L. Liverpool (Johnstone).

Unless where otherwise noted the records S. M. A. P. are the results of personal observation.

	Habitat in host.	*Locality, Observer and Date.*
1. *Labrax lupus*		
Cainocreadium labracis	Intestine	P. L. (1908).
Acanthochasmus imbutiformis	Intestine	P. L. (1906).
Bucephalus minimus	Intestine	P.
Diplectanum aequans	Gills	L. (A. Scott 1904).
Microcotyle labracis	Gills	L. (A. Scott 1904).
2. *Serranus cabrilla*		
Helicometra pulchella	Intestine	P.
Lecithaster gibbosus	Rectum	P.
3. *Mullus barbatus*		
Derogenes varicus	Stomach	P.
4. *Sparus centrodontus*		
Steringotrema pagelli	Intestine	P. (?)
Zoonogenus vividus	Rectum	A. P.
Derogenes varicus	Stomach	P.
Hemiurus communis	Stomach	A. P.
5. *Trachurus trachurus*		
Ancylocoelium typicum	Intestine	A.
Tergestia laticollis	Intestine	A. P.
Derogenes varicus	Stomach	P.
Lecithaster gibbosus	Intestine and stomach	A. P.
Hemiurus communis	Intestine	P.
Ectenurus lepidus	Stomach	A.
6. *Capros aper*		
Pharyngora bacillaris	Intestine	P.
Derogenes varicus	Stomach	P.
Hemiurus communis	Stomach	P.
Hemiurus ocreatus	Stomach	P.
7. *Scomber scombrus*		
Pharyngora bacillaris	Intestine	M. A. P. N.
Hemiurus ocreatus	Stomach	P.
Lecithocladium excisum	Stomach	M. A. P. L. (1906 recorded as *Dist. gulosum* Linton).
Octocotyle scombri	Gills	A. P. L. (A. Scott 1904).

	Habitat in host.	*Locality, Observer and Date.*
8. *Zeus faber*		
Stephanochasmus cesticillus	Intestine	P.
Zoogonoides viviparus	Rectum	P.
Derogenes varicus	Stomach	P.
Lecithaster gibbosus	Rectum	A. P.
Synaptobothrium caudiporum	Stomach	P.
9. *Trachinus draco*		
Derogenoides ovacutus	Stomach	P.
Derogenes varicus	Stomach	P.
Hemiurus communis	Stomach	A.
Rhipidocotyle viperae	Intestine	P.
Microcotyle draconis (?)	Gills	A. P.
10. *Trachinus vipera*		
Derogenes varicus	Intestine	P.
Lecithaster gibbosus	Intestine	P.
Rhipidocotyle minimum	Intestine	P
11. *Lophius piscatorius*		
Stephanochasmus baccatus (larva)	Intestine	N. (probably adventitious).
Steringophorus furciger	Intestine	N. (probably adventitious).
Derogenes varicus	Oesophagus and stomach	A. P. N.
Hemiurus communis	Stomach	A. P.
Lecithochirium rufoviride	Stomach	P.
Synaptobothrium caudiporum	Stomach	P.
Bucephalopsis gracilescens	Intestine and coeca	A. P. N.
12. *Cottus scorpius*		
Podocotyle atomon	Intestine	S. M. N.
Stephanochasmus baccatus	Intestine	S. M.
Derogenes varicus	Stomach	S. M.
Hemiurus communis	Stomach	S. N.
Prosorhynchus squamatus	Intestine and coeca	N.
Tocotrema lingua (larva)	Gills in caps	P.
13. *Cottus bubalis*		
Podocotyle atomon	Intestine	S. M. P.
Derogenes varicus	Stomach	S. P.
Hemiurus communis	Stomach	S.[1] P.
Prosorhynchus squamatus	Coeca and duodenum	S. P.
Galactosomum lacteum (larva)	Head in caps	S.
14. *Agonus cataphractus*		
Derogenes varicus	Coeca and intestine	P.

[1] In *The Marine Invertebrates and Fishes of St Andrews*, Plate VIII, Figs. 1 and 2, McIntosh records this species from the muscles. The observation appears somewhat doubtful.

	Habitat in host.	Locality, Observer and Date.
15. *Callionymus lyra*		
Lebouria varia	Intestine	S. M. P. L. (1910 recorded as *Lebouria idonea*).
Zoogonoides viviparus	Rectum	S. M. P.
Derogenes varicus	Stomach and mouth	S. P.
Lecithaster gibbosus	Intestine	S.
16. *Trigla pini*		
Helicometra pulchella	Coeca	P.
Derogenes varicus	Stomach	P.
Lecithaster gibbosus	Stomach	S. P.
Hemiurus communis	Stomach	P.
Distomum homoeostomum	Stomach	Ireland (Bellingham 1844).
Rhipidocotyle minimum	Stomach	P.
Phyllocotyle gurnardi	Gills	P.
17. *Trigla gurnardus*		
Stephanochasmus triglae	Intestine	S. N.
Derogenes varicus	Stomach	S. P. N.
Lecithaster gibbosus	Intestine	N.
Hemiurus ocreatus	Stomach	S.
Hemiurus communis	Stomach	S. P.
Rhipidocotyle minimum	Intestine	S. P.
Prosorhynchus triglae	Stomach and intestine	P.
Phyllocotyle gurnardi	Gills	N. (recorded as *Plectanocotyle caudata*).
		L. (A. Scott 1905).
		A. (T. Scott 1905).
Plectanocotyle lorenzi	Gills	A. (T. Scott 1905).
18. *Trigla hirundo*		
Derogenes varicus	Stomach and mouth	P.
Synaptobothrium caudiporum	Stomach and mouth	P.
Rhipidocotyle minimum	Intestine and coeca	P.
Trochopus pini	Gills	L. (A. Scott 1904).
Phyllocotyle gurnardi	Gills	L. (A. Scott 1904).
19. *Brama raii*		
Koellikeria filicollis	Gills	L. (1911).
20. *Cyclopterus lumpus*		
Pharyngora bacillaris	Intestine	S. P.
Derogenes varicus	Stomach	P.
21. *Cyclogaster montagui*		
Podocotyle atomon	Intestine	S. P.
Prosorhynchus squamatus	Coeca	S.
22. *Gobius ruthensparri*		
Podocotyle atomon	Intestine	S. P.
Lecithaster gibbosus	Intestine	M.

	Habitat in host.	*Locality, Observer and Date.*
23. *Gobius paganellus*		
Helicometra pulchella	Intestine and stomach	P.
Hemiurus communis	Stomach	P.
24. *Blennius gattorugine*		
Helicometra pulchella	Intestine and stomach	P.
Zoogonoides viviparus	Rectum and intestine	P.
Monorchis monorchis	Stomach	P.
25. *Blennius ocellaris*		
Steringotrema divergens	Duodenum	P.
Zoogonoides viviparus	Rectum	P.
Derogenes varicus	Mouth	P.
26. *Blennius pholis*		
Peracreadium genu	Intestine	P.
Helicometra pulchella	Intestine	P.
Lecithochirium rufoviride (larva)	Encysted in viscera	P.
Synaptobothrium caudiporum (larva)	Encysted in viscera	P.
27. *Anarrhichas lupus*		
Lebouria idonea	Intestine	S. N. (recorded as *Allocreadium* sp.).
Acanthopsolus lageniformis	Intestine	S. N. (1910).
Fellodistomum fellis	Gall bladder	S. N.
Fellodistomum agnotum	Duodenum	S.
Zoogonus rubellus	Intestine	S.
Zoogonoides viviparus	Intestine	S.
28. *Anarrhichas latifrons*		
Lebouria idonea	Intestine	A.
29. *Centronotus gunnellus*		
Podocotyle atomon	Intestine	S. M. P.
Hemiurus communis	Stomach	S.
30. *Enchelyopus viviparus*		
Podocotyle atomon	Intestine	S.
31. *Mugil chelo*		
Haploporus benedeni	Intestine	P.
Saccocoelium obesum	Intestine	P.
32. *Atherina presbyter*		
(*Podocotyle*) *atherinae*	Intestine	P.
Bacciger bacciger	Stomach	P.
33. *Gasterosteus aculeatus*		
Podocotyle atomon	Intestine	S.

	Habitat in host.	*Locality, Observer and Date.*
34. *Gastraea spinachia*		
Podocotyle atomon	Intestine	S. P.
Podocotyle reflexa	Intestine	P.
35. *Lepadogaster gouanii*		
Helicometra pulchella	Intestine	P.
Hemipera ovacaudata	Stomach	P.
Hemiurus communis	Rectum	P.
36. *Labrus mixtus*		
Helicometra pulchella	Intestine	P.
Lebouria alacris	Intestine	L. (1907 recorded as *Distomum* sp.).
37. *Labrus berggylta*		
Helicometra pulchella	Intestine	M. P.
Lebouria alacris	Intestine	M. P.
Peracreadium genu	Intestine	M. P.
Peracreadium commune	Intestine	M. P.
Lepidauchen stenostoma	Intestine	P.
Lecithaster gibbosus	Intestine	M.
Synaptobothrium caudiporum (larva)	Encysted in intestinal wall	P.
Microcotyle donovani v. Ben. and Hesse	Gills	A. (T. Scott 1911).
38. *Crenilabrus melops*		
Peracreadium commune	Intestine	P.
Lebouria alacris	Intestine	P.
Synaptobothrium caudiporum (larva)	Encysted in intestinal wall	P.
39. *Ctenolabrus rupestris*		
Lebouria alacris	Intestine	P.
Helicometra pulchella	Intestine	P.
40. *Centrolabrus exoletus*		
Lebouria alacris	Intestine	P.
41. *Gadus aeglefinus*		
Lepidapedon rachion	Intestine	S. N.
Hemiurus communis	Stomach	S.
Bucephalopsis gracilescens (larva)	Encysted in brain and nerves	N. L. (1905).
Distomum anonymum	Intestine	Ireland (Bellingham 1844)
42. *Gadus callarias*		
Lepidapedon elongatum	Intestine	N. (recorded as *Lepodora elongata*).
Stephanochasmus pristis	Intestine	M. N.
Derogenes varicus	Stomach	S. M.
Hemiurus communis	Stomach	S. M.

	Habitat in host.	*Locality, Observer and Date.*
Bucephalopsis gracilescens (larva)	Encysted in brain and nerves	N. L. (1905).
Prosorhynchus grandis	Coeca	N.
Pterocotyle morrhuae	Gills	A. (T. Scott 1901).
43. *Gadus luscus*		
Stephanochasmus caducus	Intestine and coeca	P.
Derogenes varicus	Stomach	P.
Hemiurus communis	Stomach	P.
44. *Gadus merlangus*		
Podocotyle atomon	Coeca	P.
Stephanochasmus pristis	Duodenum	P.
Stephanochasmus caducus	Intestine	N.
Stephanochasmus rhombispinosus	Intestine	N.
Distomum anonymum	Intestine	Ireland (Bellingham 1844).
Pharyngora bacillaris	Coeca and intestine	P. N. (recorded as *Pharyngora retractilis*).
Derogenes varicus	Stomach	S. M. P. L. (1907).
Lecithaster gibbosus	Intestine	M. P. N.
Hemiurus communis	Stomach	P. N. L. (1907 recorded as *Distoma appendiculatum*).
Hemiurus ocreatus	Stomach	P.
Bucephalopsis gracilescens (larva)	Encysted in brain	N.
Prosorhynchus grandis	Coeca and intestine	N.
Pterocotyle morrhuae	Gills	A. (T. Scott 1901).
Octobothrium merlangi	Gills	P. N. L. (A. Scott 1904).
45. *Gadus minutus*		
Stephanochasmus caducus	Coeca	P.
Derogenes varicus	Stomach	M. P.
Hemiurus communis	Stomach	M. P.
46. *Gadus pollachius*		
Podocotyle atomon	Intestine	M.
Lepidapedon rachion	Intestine	M. P.
Derogenes varicus	Stomach	M. P.
Hemiurus communis	Stomach	M. A. P.
Hemiurus ocreatus	Stomach	P.
Bucephalopsis gracilescens (larva)	Stomach	A.
Dactylocotyle pollachii	Gills	L. (A. Scott 1904).
47. *Gadus virens*		
Podocotyle atomon	Intestine	M.
Lepidapedon rachion	Intestine	M.
Derogenes varicus	Stomach	M.
Hemiurus communis	Stomach	M.
Octobothrium denticulatum	Gills	A.

	Habitat in host.	*Locality, Observer and Date.*
48. *Merlucius merluccius*		
Derogenes varicus	Stomach	A.
Hemiurus ocreatus	Stomach	A.
49. *Molua molva*		
Derogenes varicus	Stomach	P. N.
Hemiurus communis	Stomach	P.
Bucephalopsis gracilescens (larva)	Encysted in brain	L. (1905).
Pterocotyle palmata	Gills	N. A. (T. Scott 1901).
50. *Brosmius brosme*		
Derogenes varicus	Stomach	A.
Hemiurus communis	Stomach	A.
51. *Onos mustela*		
Podocotyle atomon	Intestine	S.
Podocotyle reflexa	Intestine, coeca and stomach	P.
52. *Onos tricirratus*		
Podocotyle atomon	Intestine	S.
Derogenes varicus	Stomach	P.
53. *Ammodytes tobianus*		
Lecithaster gibbosus	Intestine	S.
Hemiurus communis	Stomach	S. N.
Brachyphallus crenatus	Stomach	S.
54. *Ammodytes lanceolatus*		
Hemiurus communis	Stomach	P.
55. *Phycis blennoides*		
Bucephalopsis gracilescens (larva)	Encysted in brain	L. (1905).
56. *Bothus maximus*		
Zoogonoides viviparus	Rectum	S.
Derogenes varicus	Stomach	S. P.
Distomum microcotyle	Intestine	Ireland (Bellingham 1844).
57. *Bothus rhombus*		
Derogenes varicus	Stomach	S.
58. *Pleuronectes flesus*		
Podocotyle atomon	Intestine	P. L. (1907 recorded as *Distomum vitellosum*).
Derogenes varicus	Stomach	P.
59. *Pleuronectes cynoglossus*		
Steringophorus furciger	Intestine	A. N.
Zoogonoides viviparus	Rectum	A.

	Habitat in host.	*Locality, Observer and Date.*
Otodistomum cestoides (larva)	Encysted in stomach wall	A. (and T. Scott 1909 recorded in error from *P. microcephalus*).
Stephanochasmus baccatus (larva)	Encysted in muscles	N.

60. *Pleuronectes limanda*

Podocotyle atomon	Intestine	M.
Stephanochasmus baccatus (larva)	Encysted in muscles	M. N. L. (1905 recorded as *D. valdeinflatum*).
Steringophorus furciger	Intestine	S. M. A. N.
Steringotrema cluthense	Duodenum	P.
Zoogonoides viviparus	Rectum	S. M. A. P. N.
Derogenes varicus	Stomach	S. P. N.
Lecithaster gibbosus	Intestine	S.
Hemiurus communis	Stomach	A. L. (1906 recorded as *Distoma appendiculatum*).

61. *Pleuronectes microcephalus*

Stephanochasmus baccatus (larva)	Encysted in muscles	N.
Steringotrema cluthense	Intestine	M. P.
Steringophorus furciger	Intestine	N.
Zoogonoides viviparus	Rectum	S. M. P.
Derogenes varicus	Stomach	A.

62. *Pleuronectes platessa*

Podocotyle atomon	Intestine	M. N.
Lebouria varia	Intestine	M.
Steringophorus furciger	Intestine	N.
Zoogonoides viviparus	Rectum	S. M. A. P. N. L. (1909).
Derogenes varicus	Stomach	M.
Cryptocotyle concava (larva)	Encysted under skin	M.
Gasterostomum sp. (larva)	Encysted in muscles	L. (1905).

63. *Solea vulgaris*

Zoogonoides viviparus	Intestine	P.
Derogenes varicus	Stomach and intestine	P.
Epibdella soleae	Skin	West coast of Ireland (Southern 1912). L. (A. Scott 1904).

64. *Solea variegata*

Zoogonoides viviparus	Rectum and intestine	P.

65. *Hippoglossus vulgaris*

Stephanochasmus baccatus	Intestine	S. A.
Derogenes varicus	Stomach	S. A.
Lecithaster gibbosus	Intestine	S.
Hemiurus communis	Stomach	S. A.
Epibdella hippoglossi	Skin	A.

	Habitat in host.	*Locality, Observer and Date.*
66. *Drepanopsetta platessoides*		
Stephanochasmus baccatus (larva)	Encysted under skin	N.
Steringophorus furciger	Intestine	A. N.
Rhodotrema ovacutum	Intestine	A. N.
Zoogonoides viviparus	Rectum	A. N.
Derogenes varicus	Stomach	N.
Lecithaster gibbosus	Intestine	M.
Hemiurus communis	Stomach	M.
67. *Zeugopterus punctatus*		
Helicometra pulchella	Intestine	P.
Hemiurus communis	Stomach	P.
68. *Zeugopterus norvegicus*		
Podocotyle atomon	Rectum	P.
Lecithaster gibbosus	Intestine	P.
69. *Salmo trutta*		
Bunodera nodulosa	Intestine	P.
Derogenes varicus	Stomach	P.
Lecithaster gibbosus	Intestine	A.
70. *Salmo salar*		
Distomum miescheri	Oesophagus	Tweed (Tosh 1905).
Derogenes varicus	Oesophagus, stomach and intestine	(Tosh 1905.)
Hemiurus ocreatus	Stomach	(Tosh 1905.)
71. *Osmerus eperlanus*		
Lecithaster gibbosus	Intestine	S.
72. *Argentina sphyraena*		
Lecithophyllum botryophoron	Intestine	S.
73. *Clupea harengus*		
Hemiurus ocreatus	Stomach	S. M.
74. *Clupea pilchardus*		
Hemiurus ocreatus	Stomach	P.
75. *Clupea sprattus*		
Derogenes varicus	Stomach	S.
Lecithaster gibbosus	Intestine	S.
Hemiurus ocreatus	Stomach	S.
76. *Anguilla vulgaris*		
Podocotyle atomon	Intestine	P.
Helicometra pulchella	Intestine	P.
Hemiurus communis	Stomach	S.
Lecithochirium rufoviride	Stomach	S. P.

		Habitat in host.	*Locality, Observer and Date.*
77.	*Conger conger*		
	Helicometra pulchella	Intestine	M. P.
	Derogenes varicus	Stomach	P.
	Lecithochirium rufoviride	Stomach	M. A. P.
	Prosorhynchus aculeatus	Intestine	M. P.
	Prosorhynchus crucibulum	Intestine	M. P.
78.	*Belone vulgaris*		
	Lecithaster gibbosus	Intestine	L. (1907 recorded as *Distoma mollissimum*).
79.	*Mola mola*		
	Dihemistephanus lydiae	Intestine	S.
	Tristomum molae	Gills	W. coast Ireland (Southern 1912).
80.	*Syngnathus acus*		
	Podocotyle syngnathi	Intestine	P.
81.	*Nerophis aequoreus*		
	Podocotyle atomon	Intestine	P.
	Podocotyle syngnathi	Intestine	P.
	Hemiurus communis	Intestine	P.
82.	*Siphonostoma typhle*		
	Podocotyle syngnathi	Intestine	P.
	Acanthochasmus imbutiformis (larva)	Encysted in gills	P.
83.	*Chimaera monstrosa*		
	Calicotyle affinis	Gills	A. (T. Scott 1911).
	Octobothrium leptogaster	Gills	A. (T. Scott 1911).
84.	*Mustelus vulgaris*		
	Ptychogonimus megastomus	Stomach	P.
85.	*Acanthias vulgaris*		
	Onchocotyle appendiculata	Gills	N. L. (A. Scott 1904).
86.	*Scyllium canicula*		
	Paracotyle caniculae	Gills	L. (1911).
87.	*Rhina squatina*		
	Pseudocotyle squatinae	Skin	P.
88.	*Trygon pastinacea*		
	Thaumatocotyle concinna	Nasal fossae	A. (T. Scott 1904).
	Heterocotyle pastinaceae	Gills	A. (T. Scott 1904).
89.	*Raia batis*		
	Otodistomum cestoides	Oesophagus	A. (T. Scott 1909).
90.	*Raia circularis*		
	Calicotyle krøyeri	Rectum	P.

	Habitat in host.	*Locality, Observer and Date.*
91. *Raia clavata*		
Calicotyle kr∅yeri	Rectum, cloaca	P. L. (A. Scott 1904).
92. *Raia maculata*		
Calicotyle kr∅yeri	Cloaca	P.
93. *Raia macrorhyncha*		
Otodistomum cestoides	Stomach	A.
94. *Raia radiata*		
Otodistomum cestoides	Stomach	N. (recorded as *O. veliporum*).
Calicotyle kr∅yeri	Cloaca, gills	N.

LIST OF TREMATODE PARASITES RECORDED FROM BRITISH MARINE FISHES OUTSIDE BRITISH WATERS AND HITHERTO NOT RECORDED FROM THE BRITISH AREA; ARRANGED ACCORDING TO HOSTS.

	Habitat in host.
1. *Labrax lupus*	
Acanthochasmus praeteritus Looss	Intestine
Sterrhurus musculus Looss	Stomach
Lecithochirium gravidum Looss	Stomach
Udonella lupi v. Ben. and Hesse	Skin
2. *Serranus cabrilla*	
Helicometra fasciata (Rud.)	Intestine
Sterrhurus musculus Looss	Stomach
(*Distomum*) *microsoma* Rud.	Intestine
3. *Mullus barbatus*	
(*Podocotyle*) *furcata* (Bremser)	Intestine
Proctotrema bacilliovatum Odhner	Intestine
Lasiotocus mulli (Stoss.)	Intestine
Aponurus laguncula Looss	Oesophagus and stomach
4. *Sparus centrodontus*	
Encotyllabe pagelli v. Ben. and Hesse	Mouth
5. *Trachurus trachurus*	
Pharyngora polonii (Molin)	Intestine
Tergestia acanthocephala (Stoss.)	Intestine
Haplocladus typicus Odhner	Intestine
Pristisomum pumex Looss	Intestine
Aphanurus stossichi (Monticelli)	Oesophagus and stomach
Lecithocladium excisum (Rud.)	Stomach
(*Cryptogonimus*) *tubarius* Rud.	Intestine
Gastrocotyle trachuri v. Ben. and Hesse	Gills
Pseudaxine trachuri Par. and Per.	Gills

	Habitat in host.
6. *Capros aper*	
Lecithochirium rufoviride (Rud.)	Intestine
7. *Scomber scombrus*	
Podocotyle atomon (Rud.)	Intestine
Lecithaster gibbosus (Rud.)	Rectum
Pleurocotyle scombri (Grubi)	Gills
Didymozoon scombri Taschenberg	Mouth
8. *Trachinus draco*	
Helicometra pulchella (Rud.)	Intestine
Lecithaster gibbosus (Rud.)	Intestine
Aponurus laguncula Looss	Oesophagus and stomach
Sterrhurus musculus Looss	Stomach
(*Gasterostomum*) *vivae* v. Ben.	Intestine
9. *Trachinus vipera*	
Rhipidocotyle viperae v. Ben.	Intestine
10. *Lophius piscatorius*	
Stephanochasmus hystrix (Dujardin)	Stomach
Stephanochasmus cesticillus (Molin)	Intestine
Stephanochasmus caducus Looss	Intestine
Leptosoma obscurum Stafford	Intestine
Xenodistomum melanocystis Stafford	Intestine
Otodistomum cestoides (v. Ben.) (=*D. nigrescens* Olsson)	Stomach
Lecithochirium physcon Lühe	Stomach
Lecithochirium grandiporum (Rud.)	Stomach
Sterrhurus musculus Looss	Stomach
Ectenurus lepidus Looss	Stomach
Lecithocladium excisum (Rud.)	Stomach
(*Distomum*) *macroporum* Monticelli	Stomach
11. *Cottus scorpius*	
Peracreadium commune (Olsson)	Intestine
Stephanochasmus sobrinus (Levinsen)	Intestine
Acanthopsolus oculatus (Levinsen)	Intestine and coeca
Steringophorus furciger (Olsson)	Intestine
Genarches mülleri (Levinsen)	Stomach
Lecithaster gibbosus (Rud.)	Intestine
Hemiurus levinseni Odhner	Stomach
Brachyphallus crenatus (Rud.)	Stomach and mouth
Galactosomum lacteum Jägerskiöld (larva)	Dura mater
Gyrodactylus groenlandicus Levinsen	Skin
(*Distomum*) *granulum* Rud.	Intestine
12. *Cottus bubalis*	
Peracreadium commune (Olsson)	Intestine
13. *Agonus cataphractus*	
(*Distomum*) *aspidophori* v. Ben.	Intestine

		Habitat in host.
14.	*Trigla pini*	
	(*Distomum*) *triglae* Rud.	Intestine
	Trochopus pini (v. Ben. and Hesse)	Gills
15.	*Trigla gurnardus*	
	Podocotyle reflexa (Creplin)	Intestine
	Liocerca bonnieri (Monticelli)	Gills
	Udonella triglae v. Ben. and Hesse	Skin
	Platycotyle gurnardi v. Ben. and Hesse	Gills
	(*Distomum*) *soleaeforme* Rud.	Stomach
	(*Distomum*) *cryptobothrium* v. Ben.	Intestine
16.	*Trigla hirundo*	
	Trochopus tubiporus (Diesing)	Gills
	Axine triglae v. Ben. and Hesse	Gills
	Echinella hirundinis v. Ben. and Hesse	Skin
17.	*Trigla lineata*	
	"*Distomum appendiculatum*" Rud.	Stomach and intestine
18.	*Brama raii*	
	Encotyllabe nordmanni Diesing	Throat
	Microcotyle acanthurum Par. and Per.	Gills
19.	*Cyclopterus lumpus*	
	Podocotyle reflexa (Creplin)	Intestine
	Lecithophyllum botryophoron (Olsson)	Intestine
	Gasterostomum sp.	Intestine
	Gyrodactylus elegans	Gills
20.	*Gobius paganellus*	
	(*Distomum*) *foliaceum* Molin	Intestine
21.	*Gobius minutus*	
	Gyrodactylus elegans v. Nordmann	Gills
	(*Distomum*) *flavescens* v. Ben.	Intestine
	(*Distomum*) *gobii* Rentsch	Intestine
22.	*Blennius gattorugine*	
	Steringotrema divergens (Rud.)	Intestine
23.	*Blennius ocellaris*	
	Helicometra pulchella (Rud.)	Intestine
	Diphterostomum brusinae Stossich	Rectum
	Proctoeces maculatus (Looss)	Intestine
24.	*Anarrhichas lupus*	
	Podocotyle atomon (Rud.)	Stomach
	Zoogonoides subaequiporus Odhner	Rectum
	? *Neophasis pusilla* Stafford	Urinary bladder
	Lepidophyllum steenstrupi Odhner	Urinary bladder
	Derogenes plenus Stafford	Intestine
	(*Distomum*) *anarrhichae* Rathke	Intestine

		Habitat in host.
25.	*Mugil chelo*	
	Haplosplanchnus pachysomus (Eysenhardt)	Intestine
	Dicrogaster perpusillus Looss	Intestine
	Dicrogaster contractus Looss	Intestine
	Haploporus lateralis Looss	Intestine
	Saccocoelium tensum Looss	Intestine
	Gyrodactylus sp. v. Ben.	Gills
26.	*Mugil capito*	
	Haplosplanchnus pachysomus (Eysenhardt)	Intestine
27.	*Gasterosteus aculeatus*	
	? *Proponyge ventricosa* (Rud.)	Intestine
	Brachyphallus crenatus (Rud.)	Stomach
	Diplozoon paradoxum v. Nordmann	Gills
	Gyrodactylus elegans v. Nordmann	Gills
28.	*Gastraea spinachia*	
	(*Distomum*) *palmatum* Rentsch	Intestine
	(*Distomum*) *coronatum* Rentsch	Intestine
	(*Distomum*) *gobii* Rentsch	Intestine
	(*Monostomum*) *dubium* Cobbold	Peritoneum in cysts
29.	*Naucrates ductor*	
	(*Distomum*) *giardii* Stossich	Intestine
30.	*Thynnus pelamys* (= *T. vulgaris*?)	
	Hirudinella clavata (Rud.)	Stomach
	Wedlia bipartita (Wedl)	Gills
	Didymozoon pretiosum Ariola	Gills
	Didymocystis reniformis Ariola	Gills
	Tristomum onchidiocotyle Setti	Skin
	Hexacotyle thynni Blainvills	Skin
31.	*Lampris luna* (= *L. guttatus*?)	
	Didymozoon tenuicolle (Rud.)	Muscles
32.	*Sebastes norvegicus*	
	Podocotyle atomon (Rud.)	Intestine
	Peracreadium commune (Olsson)	Intestine
	Derogenes varicus (Müller)	Stomach
33.	*Xiphias gladius*	
	Hirudinella clavata (Rud.)	Stomach
	Tristomum coccineum Cuvier	Gills
	Tristomum papillosum Diesing	Gills
	"*Distomum dendriticum*" Rud.	Intestine
34.	*Labrus mixtus*	
	Peracreadium commune (Olsson)	Intestine
	Helicometra fasciata (Rud.)	Stomach
	(*Allocreadium*) *colligatum* Wallin (=*D. fasciatum* Stossich 1885)	Intestine
	Lecithaster gibbosus (Rud.)	Rectum

		Habitat in host.
35.	*Labrus berggylta* (= *maculatus*)	
	Cainocreadium labracis (Dujardin)	Rectum
	Zoogonus rubellus (Olsson)	Rectum
	Diphterostomum brusinae Stossich	Rectum
	Derogenes varicus (Müller)	Intestine
36.	*Crenilabrus melops*	
	Helicometra pulchella (Rud.)	Intestine
	Helicometra fasciata (Rud.)	Intestine
37.	*Gadus aeglefinus*	
	Podocotyle atomon (Rud.)	Intestine
	Lecithaster gibbosus (Rud.)	Stomach and intestine
	Proctophantastes abyssorum Odhner	Rectum
38.	*Gadus callarias*	
	Podocotyle atomon (Rud.)	Intestine
	Lepidapedon rachion (Cobbold)	Intestine
	Nitzschia papillosa Linton	Gills
39.	*Gadus luscus*	
	Dactylocotyle lusci v. Ben. and Hesse	Skin
40.	*Gadus minutus*	
	Stephanochasmus pristis (Deslongch.)	Intestine
	Bucephalopsis gracilescens (Rud.) (larva)	Brain in cysts
	Octobothrium denticulatum Olsson	Gills
41.	*Gadus pollachius*	
	Udonella pollachii v. Ben. and Hesse	Skin
42.	*Gadus virens*	
	Bucephalopsis gracilescens (Rud.) (larva)	Brain in cysts
43.	*Merlucius merluccius*	
	Lepidapedon rachion (Cobbold)	Intestine
	Udonella merlucii v. Ben.	Skin
	Acanthocotyle merlucii v. Ben.	Gills
	(*Holostomum*) *clavus* Molin	Intestine
44.	*Molua molva*	
	(*Podocotyle*) *furcata* Bremser	Intestine
	Pteronella molvae v. Ben. and Hesse	Skin
	(*Distomum*) *fulvum* Rud.	Intestine
	(*Distomum*) *nigrescens* Olsson	Stomach
45.	*Brosmius brosme*	
	"*Gasterostomum armatum*" Molin	Coeca and duodenum
46.	*Onos mustela* (= *Motella vulgaris*?)	
	Stephanochasmus pristis (Deslongch.)	Intestine
	Lecithocladium excisum (Rud.) (immature)	Stomach
	(*Distomum*) *osculatum* Looss	Intestine

	Habitat in host.
(*Distomum*) *ventricosum* Rud.	Intestine
(*Distomum*) *motellae* v. Ben.	Intestine
(*Distomum*) *fulvum* Rud.	Intestine
(*Distomum*) sp. v. Ben.	Intestine
47. *Ammodytes tobianus*	
Hemiurus ocreatus (Rud.)	Stomach
Gyrodactylus sp. v. Ben.	Gills
(*Distomum*) *tobiani* Krøyer	Abdominal cavity
48. *Phycis blennoides*	
Hemiurus levinseni Odhner	Mouth
49. *Raniceps raninus*	
Podocotyle atomon (Rud.)	Intestine
50. *Bothus maximus*	
Podocotyle atomon (Rud.)	Mouth
Stephanochasmus hystrix (Dujardin) (larva)	Peritoneum in cysts
Lecithochirium rufoviride (Rud.)	Intestine
Lecithochirium gravidum Looss	Stomach
Synaptobothrium caudiporum (Rud.)	Stomach
Sterrhurus musculus Looss	Stomach
(?) *Calicotyle krøyeri* Diesing	Skin
(*Distomum*) *rhombi* v. Ben.	Stomach
51. *Bothus rhombus*	
Synaptobothrium caudiporum (Rud.)	Stomach
52. *Pleuronectes flesus*	
Cainocreadium labracis (Dujardin)	Intestine
Steringophorus furciger (Olsson)	Stomach
Zoogonoides viviparus (Olsson)	Intestine
Aporocotyle simplex Odhner	Gills
"*Distomum appendiculatum*" Rud.	Stomach and intestine
(*Distomum*) sp. Wagener	Intestine
53. *Pleuronectes limanda*	
Haplocladus minor Odhner	Intestine
Brachyphallus crenatus (Rud.)	Stomach
Aporocotyle simplex Odhner	Gills
54. *Pleuronectes microcephalus*	
Podocotyle atomon (Rud.)	Intestine
55. *Pleuronectes platessa*	
Stephanochasmus hystrix (Dujardin) (larva)	Gills in cysts
56. *Solea vulgaris*	
Podocotyle atomon (Rud.)	Intestine and stomach
(*Podocotyle*) *furcata* (Bremser)	Intestine
(*Distomum*) *microstomum* Rud.	Intestine
(*Distomum*) *soleae* Dujardin	Intestine
"*Distomum appendiculatum*" Rud.	Stomach and intestine

	Habitat in host.
57. *Hippoglossus vulgaris*	
Steganoderma formosum Stafford	Coeca and intestine
Stenakron vetustum Stafford	Intestine
"*Gasterostomum armatum*" Molin	Coeca and duodenum
Tristomum uncinatum Monticelli	Skin
58. *Arnoglossus laterna*	
Synaptobothrium caudiporum (Rud.)	Intestine
59. *Salmo salar*	
Podocotyle atomon (Rud.)	Intestine
Podocotyle reflexa (Creplin)	Stomach
Lecithaster gibbosus (Rud.)	Intestine
Brachyphallus crenatus (Rud.)	Stomach
60. *Salmo trutta*	
Stephanophiala laureata (Zeder)	Intestine
Azygia tereticollis (Rud.)	Stomach
Brachyphallus crenatus (Rud.)	Stomach
Octobothrium sagittatum Leuckart	Gills
(*Distomum*) *truttae* Moulinié	Eye in cysts
"*Distomum appendiculatum*" Rud.	Stomach
61. *Osmerus eperlanus*	
Lecithochirium rufoviride (Rud.)	Intestine
Brachyphallus crenatus (Rud.)	Stomach
Tetracotyle ovata v. Linstow	Peritoneum in cysts
(*Distomum*) *microphylla* v. Ben.	Intestine
(*Distomum*) *macrobothrium* v. Ben.	Intestine
(*Monostomum*) *gracile* Rud.	Abdominal cavity
62. *Clupea harengus*	
Derogenes varicus (Müller)	Oesophagus and stomach
Lecithaster gibbosus (Rud.)	Rectum
Lecithaster confusus Odhner	Rectum
Octoplectanum harengi v. Ben. and Hesse	Gills
63. *Clupea pilchardus*	
Hemiurus rugosus Looss	Stomach
Aphanurus stossichi (Monticelli)	Stomach
Octoplectanum pilchardi v. Ben. and Hesse	Gills
"*Trematodum* sp." Monticelli	Stomach
64. *Clupea sprattus*	
Gasterostomum clupeae v. Ben.	Intestine
Octoplectanum heterocotyle v. Ben.	Gills
(*Distomum*) *minimum* v. Ben.	Intestine
65. *Anguilla vulgaris*	
Peracreadium commune (Olsson)	Intestine
Helicometra fasciata (Rud.)	Intestine
Derepristis inflata (Molin)	Intestine

	Habitat in host.
Azygia tereticollis (Rud.)	Gills
Lecithaster gibbosus (Rud.)	Rectum
Derogenes varicus (Müller)	Stomach
Sterrhurus grandiporus (Rud.)	Stomach
Sterrhurus musculus Looss	Stomach
Lecithochirium gravidum Looss	Stomach
Bucephalus polymorphus Baer	Intestine
"*Distomum ventricosum*" Rud.	Intestine
(*Distomum*) *globiporum* Rud.	Intestine
(*Distomum*) *polymorphum* Rud.	Intestine

66. *Conger conger*

Podocotyle atomon (Rud.)	Intestine
Lecithochirium conviva Lühe	Stomach
Lecithochirium gravidum Looss	Stomach
Sterrhurus grandiporus (Rud.)	Oesophagus
Sterrhurus fusiformis (Lühe)	Stomach
(*Distomum*) *calceolus* Molin	Intestine
(*Distomum*) *vitellosum* Linton	Intestine

67. *Belone vulgaris*

Bucephalopsis gracilescens (Rud.) (larva)	Viscera in cysts
"*Distomum belones vulgaris*" Wedl (larva)	Pericardium in cysts

68. *Engraulis encrasicholus*

Aphanurus virgula Looss	Oesophagus and stomach
Aponurus laguncula Looss	Oesophagus and stomach

69. *Alosa vulgaris*

Hemiurus appendiculatus (Rud.)	Intestine
Hemiurus ocreatus (Rud.)	Stomach and intestine
Octoplectanum lanceolatum Diesing	Gills
Octobothrium alosae v. Ben. and Hesse	Gills

70. *Mola mola*

Stenocollum fragile Linton	Intestine
(*Orophocotyle*) *foliatum* Linton	Intestine
Accocoelium macrocotyle (Diesing)	Intestine
Accocoelium contortum (Rud.)	Gills
Accocoelium nigroflavum (Rud.)	Stomach
Nematobothrium benedenii Monticelli	Gills
Nematobothrium molae Maclaren	Gills in cysts
Nematobothrium taenioides Monticelli	Gills
Koellikeria filicollis (Rud.)	Intestine
Tristomum rudolphianum Diesing	Gills
Tristomum papillosum Diesing	Gills
Tristomum cephala Risso	Skin

71. *Nerophis aequoreus*

(*Allocreadium*) *tumidulum* (Rud.)	Intestine

	Habitat in host.
72. *Syngnathus acus*	
(*Allocreadium*) *tumidulum* (Rud.)	Intestine
Lecithochirium gravidum Looss (larva)	Peritoneum in cysts
73. *Acipenser sturio*	
Deropristis hispida (Abildgaard)	Intestine
Derogenes varicus (Müller)	Intestine
Sterrhurus grandiporus (Rud.)	Oesophagus and stomach
Sterrhurus musculus Looss	Stomach
Lecithochirium rufoviride (Rud.)	Stomach and intestine
Brachyphallus crenatus (Rud.)	Intestine
Nitzschia elegans Baer	Gills
74. *Chimaera monstrosa*	
Otodistomum veliporum (Creplin) (= *Distomum insigne*)	Oesophagus
Macraspis elegans Olsson	Skin
75. *Mustelus vulgaris*	
Probolitrema richiardii (Lopez)	Abdominal cavity
Onchocotyle appendiculata Diesing	Gills
(*Distomum*) *megalocotyle* Monticelli	Stomach
76. *Galeus vulgaris*	
Ptychogonimus megastomus (Rud.)	Stomach
Onchocotyle appendiculata Diesing	Gills
77. *Acanthias vulgaris*	
Otodistomum veliporum (Creplin)	Stomach
Probolitrema richiardii (Lopez)	Abdominal cavity
Onchocotyle abbreviata Olsson	Gills
Pseudocotyle apiculatum Olsson	Skin
78. *Scyllium canicula*	
Diphterostomum betencourti Monticelli	Rectum
Onchocotyle appendiculata Diesing	Gills
79. *Scyllium catulus*	
Ptychogonimus megastomus (Rud.)	Stomach
Onchocotyle appendiculata Diesing	Gills
80. *Carcharias glaucus*	
Ptychogonimus megastomus (Rud.)	Stomach
81. *Laemargus borealis*	
Squalonchocotyle borealis v. Ben.	Gills
82. *Raia batis*	
Onchocotyle appendiculata Diesing	Gills
Calicotyle krøyeri Diesing	Rectum
Merizocotyle diaphanum Cerfontaine	Gills
(*Distomum*) *fulvum* Rud.	Stomach

	Habitat in host.
83. *Raia clavata*	
Otodistomum cestoides (v. Ben.)	Stomach
Lecithochirium rufoviride (Rud.)	Intestine
Onchocotyle emarginata Olsson	Gills
Stichocotyle nephropis Cunningham	Bile ducts
84. *Raia radiata*	
Acanthocotyle verrilli Goto	Skin
85. *Raia fullonica*	
Otodistomum cestoides (v. Ben.)	Stomach and intestine
86. *Raia lintea*	
Otodistomum cestoides (v. Ben.)	Stomach

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NOTE ON A CASE OF "TICK-PARALYSIS" IN AUSTRALIA.

By C. STRICKLAND, M.A., B.C.

In view of the interesting papers on "Tick Paralysis" published in *Parasitology* (VI. 283–297, 299–301, VII. 95–104) by Hadwen and Nuttall, it appears desirable to place the following case on record as described by the mother of the child:

"My son, aged 11 years, had the misfortune to get a tick in his ear while in the bush in Australia, he was a boy scout and one Saturday afternoon he was out with the other boy scouts and must have got the tick then but did not know it; four days after he complained of feeling very sick and giddy, and as he was at boarding-school, the matron put him to bed and treated him for a bilious attack, he got much worse, as all his muscles seemed to be affected, he could not walk without assistance and his face was quite crooked on one side; the Doctor was examining him and happened to touch his ear and the child exclaimed and said it hurt very much, then the Doctor examined his ear and found a very large tick (it had been there for a week): of course we all expected him to get well quickly once the tick had been removed, but no, his knees were very weak indeed and his face was no better; a consultation was held, between the school Doctor and one of Sydney's best specialists (infantile paralysis was hinted at); however, with careful feeding and medicine the child was well again in ten days after the tick was removed. The Doctor said the tick had bitten near the facial nerve and also had poisoned his blood."

Note by Geo. H. F. Nuttall.

Unfortunately the tick was neither preserved nor identified. As it was stated to be very large we may presume that it was an engorged female. The onset of the symptoms would appear to have coincided with the period of rapid engorgement of the parasite as recorded in connection with the experimental cases cited by Hadwen and Nuttall. The occurrence of paralysis affecting the face and legs and the fact that the child was well again within ten days of the removal of the tick indicate, in the absence of any other explanation, that this may well have been a case of "tick paralysis."

THE NUCLEAR CHANGES IN *AGRIPPINA BONA* STRICKLAND[1].

By C. STRICKLAND, M.A., B.C.

Travelling Medical Entomologist, Federated Malay States.

(*From the Malaria Bureau, Kuala Lumpur, F.M.S.*)

Lewin[2] has recently described the account which I gave of the nuclear changes and sporulation of *Agrippina bona* as a remarkable narrative.

His own description, however, differs but slightly from mine, as the following table will show.

	My account	*Lewin's account*
1.	The karyosome consists of a close-wound skein of chromatin in the young trophozoite.	There is no evidence of this.
2.	The nuclear "spherules" do not become chromatinised.	They become chromatic[3], but finally in the cyst achromatic again.
3.	In the cyst when the partition between the sporonts has disappeared the nucleus can no longer be seen, the membrane goes, the spherules go, and the karyosomatic band goes.	The nuclear membrane disappears, the spherules go, and only a little chromatin remains in the tropho-nucleus.
4.	The details of the differentiation of the endoplasm into spores is very difficult to make out. Clear areas (sporocysts) loom up and resolve themselves into spores.	Mitosis occurs, gametes are formed which conjugate to form sporocysts and spores.

These are the main differences in the accounts and it is therefore difficult to see why Lewin should have found mine so remarkable. Lewin certainly fills up a gap in my account by his description of the

[1] Strickland (1912). *Parasitology*, v, 97–108.
[2] Lewin (1913). *Parasitology*, vi, 257–264.
[3] "Chromatinic" according to Minchin.

mitotic changes but it was not the incompleteness of my description which he appears to criticise.

I contend, however, that the narrative which I gave is correct with regard to these points.

The structure of the karyosome in the young trophozoite.

I say this is a close-wound skein, because I have seen it. Moreover, the older trophozoites, Lewin admits, have a band-like karyosome, and it is reasonable in itself to suppose that this band is derived from a pre-existing band rather than from a globule of chromatin. Lewin's figure of a section cut through a young karyosome may perhaps be considered to have resulted from distortion, and that it is no thinner than an optical section of the entire karyosome.

The presence of chromatin in the spherules.

I admit that sometimes the spherules become distinctly blue after staining with Haidenhain, but only rarely. It is not, however, the rich deep blue that chromatin takes on, but looks rather like a weak "solution" of the stain. Moreover, Romanowsky stains did not give at any time a chromatin reaction although Lewin says "it seems probable (sic)... when they contain chromatin they may stain purple" (*i.e.* the chromatin reaction). Lewin admits that finally the spherules lose all their "chromatin." My own experience has been that they never hold chromatin in the sense that the karyosome does. It is surely not unreasonable to find chromatin in the spherules when it can be discerned in the sporozoites.

The disappearance of the nucleus.

I stated that the nucleus in the cyst completely disappeared, and as far as the membrane and spherules are concerned Lewin agrees with me, but his sections show some karyolymph and patches of (?) chromatin remaining. In the first place it is difficult to see how the karyolymph remains when the membrane goes, and I think it fair to assume that ultimately it also disappears. Secondly, certain of Lewin's results have shown that the impoverished trophonucleus retains a very small amount of faintly staining chromatin (the remains of the karyosome

presumably). It is therefore probable that on occasions *all* is lost, which would account for my not being able to detect it. The truth must therefore be that the chromatin, which Lewin admits only stains but faintly, either remains in small amount, or completely disappears.

It is not my description which is remarkable, for it is correct as far as it goes; it is the creature which is remarkable. It is to be hoped that some explanation will be forthcoming of the nuclear spherules, now that Lewin has happily shown that the sporulation is homologous to that in other Gregarines.

ON A NEW FAMILY AND FIVE NEW GENERA OF MALLOPHAGA.

By LAUNCELOT HARRISON, B.Sc.

Exhibition of 1851 *Research Scholar of the University of Sydney.*

(*From the Quick Laboratory, Cambridge.*)

(With Plates XXVI and XXVII and 3 Text-figures.)

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Introductory.

The present paper comprises descriptions of five new species of Mallophaga, included in five new genera.

One of these genera, *Heteroproctus*, has served to connect up three existing genera, *Ornithobius*, *Akidoproctus*, and *Bothriometopus*, the four forming a compact group for which I have established a new family, Akidoproctidae.

This family is of interest, as it demonstrates the artificiality of the

present classification of the ISCHNOCERA; which is so largely based upon the comparative length and breadth of species, and upon sexual dimorphism of the antennae. Kellogg (1896) has divided the ISCHNOCERA into two families, Trichodectidae and Philopteridae. Mjöberg (1910) has further divided the Philopteridae into four families, Lipeuridae, Eurymetopidae, Goniodidae, and Docophoridae. It will be noted that Kellogg's name Philopteridae has been dropped, unless we assume that Mjöberg intended it to contain the remaining ISCHNOCERAN genera, with which he has not dealt. These are *Nesiotinus* Kellogg, *Ornicholax* Carriker, *Akidoproctus* Piaget, *Giebelia* Kellogg, *Bothriometopus* Taschenberg, *Philoceanus* Kellogg, *Trabeculus* Rudow, *Oncophorus* Piaget = *Rallicola* Johnston and Harrison, and *Kelloggia* Carriker. Neumann has, however, pointed out (1906, p. 58) that *Philopterus* must replace *Docophorus*, so that Kellogg's name must stand for the family including *Philopterus* and *Degeeriella*. It may be noted in passing that Mjöberg's name Eurymetopidae must be replaced by Docophoroididae; as *Docophoroides* Giglioli (1864) has priority over *Eurymetopus* Taschenberg (1882), and is quite validly diagnosed, despite Neumann's assertion (1912, p. 196) to the contrary. Of these genera, not dealt with by Mjöberg, *Ornicholax* and *Kelloggia* fall into the Goniodidae; *Nesiotinus*, which seems to be an immature form, must, if correctly described, form the type genus of a new family Nesiotinidae, with the characters of the genus; *Giebelia*, *Philoceanus*, and *Trabeculus* find place in Waterston's (1914, p. 290) family Giebeliidae; *Rallicola* must be included tentatively in the Philopteridae; while *Akidoproctus* and *Bothriometopus* would, according to the present family diagnoses, fall respectively into the Philopteridae and Lipeuridae. But, as I shall show later, these two genera are closely related, so that a classification which separates them is manifestly absurd.

As a matter of fact, my present investigations, so far as they have gone, have confirmed me in the opinion that the genera themselves need a drastic revision before the family groupings can be satisfactorily arranged. And for this purpose a variety of characters must be called into use, which have hitherto been ignored. I hope, at a future date, to be in a position to undertake this revision. In the meantime, no particular purpose will be served by discussing the present family divisions. But the difficulty that I have mentioned above arises also in the case of the genus *Psittaconirmus*, which I have not placed in a family, as the only family open to receive it is the Lipeuridae, with which I can easily convince myself that it has no immediate affinity.

Sub-order Amblycera.

Family Menoponidae.

Genus *Eomenopon*, nov.

Neumann (1912, p. 353) has founded a sub-genus *Menacanthus* for the reception of certain forms, previously included in *Menopon*, which bear spinous processes on the ventral surface of the head. He thinks (1912, p. 353) "qu'on accueillera avec satisfaction la subdivision que je propose dans le genre *Menopon*." Possibly the satisfaction would have been greater had a less heterogeneous assemblage of forms been included in the sub-genus.

The new genus which I propose also has spines upon the ventral surface of the head. But it need not, on that account, be confused with any of the various members of the sub-genus *Menacanthus*, for the spines are in a different position; nor does its separation depend upon the spines alone, for the frontal margin carries a deep lateral cleft, similar to that found in *Heterodoxus*, which is more pronounced in the young than in the adult. This apparently primitive character will be further discussed below. The genus, which would seem to be characteristic of Australian lorikeets (Loriidae), may be diagnosed as follows:

Menoponidae with the chitinous framework for support of the mandibles continued forwards to the anterior margin of the head, thence curving downwards and backwards to form a pair of stout freely-projecting spinous processes, which reach to the anterior border of the mandibles; with a deep narrow cleft in the side of the forehead, extending to the inner border of the antennary fossa; with winged prothorax, short, but distinct, mesothorax, and metothorax differing from the abdominal segments; and with abdomen of nine distinct segments.

Eomenopon denticulatus, n. sp. Figs. 5, 6, 16.

Head. Parabolic in front, evenly rounded to the temporal angles, with a very slight emargination in front of the eye. Occiput slightly concave. Chitinous supporting structures of unusual form, consisting of two broad straight bars giving articulation to the mouthparts, which run parallel from the anterior margin of the head to where they are met by the forward ventral continuation of the temporal border (the dotted line in Text-fig. 1). At this point each bar divides into two; one branch following the inner margin of the antennary fossa,

and widening to form a prominent dark-brown blotch at the inner end of the frontal cleft; the other passing straight backwards, and round the hind border of the mentum, to meet its fellow of the opposite side, the course being indicated by the inner dotted lines in the Text-figure. Just internal to the postero-lateral angles of the mentum, a pair of short bands run backwards along the borders of the sub-mentum. On the lateral margin of the forehead a slit-like frontal cleft, with chitinous lips, runs inwards. The rounded dorsal swelling, so characteristic of Menoponidae in general, is confined to the area between this cleft and the eye.

The prothorax has narrow elongate wings. The shoulders are squarely rounded, the sides straight and convergent, the postero-lateral angles rounded, and the hind border only slightly convex. A strong interscapular bar runs across the pronotum, joining the scapular bands which bound the raised central region. Another vaguely defined band runs from the shoulder inside the scapular, overlying the clavicular, a structure found also in *Heterodoxus*. *The mesothorax* sends two conical projections under the pronotum, the inner anterior borders of which are strongly chitinous, and continue backwards and inwards as a pair of stout apodemes within the segment. Dorsal to these, a straight bar passes across the full width of the segment, from the outer ends of which pass downwards the bands supporting the acetabular margins for the second legs. This bar has in most Amblycera the form of two strong arches. *The metathorax* is narrow anteriorly, its straight sides diverging rapidly, the postero-lateral angles being acute, and the hind margin straight. *The prosternum* bears a well-defined blotch of characteristic shape, with lateral projections for articulation with the clavicular. It is remarkable for being naked, except for some broad flat denticles towards its posterior margin, which fade away gradually in front, leaving a slight scaly appearance. These denticles, which have suggested the specific name, are much better developed in the young, covering the mentum, sub-mentum, prosternum, and mesosternum; but in the adult they become reduced to a few about the bases of the palps, and those above-mentioned on the prosternum. *The mesosternum* is an oblong plate formed by the fusion of the anterior inter-coxal bands, and carrying three hairs, two in front and one behind. *The metasternum* is a broad plate, covered with hairs. *The coxae* of the first pair have a rectangular anterior prolongation, and acuminate posterior ends, terminating in a stout spinous hair, with strongly arched inner borders.

The abdomen, in shape, appearance, and general arrangement of the chaetotaxy, is very like that of *Heterodoxus*; from which, however, it differs in the terminal segments, and in having the two anterior segments devoid of stigmata, in place of the first only. It is widest at the fourth and fifth segments, and the posterior end is more or less rounded in both sexes. The pleura are clearly marked off, their borders bearing a narrow lateral band, swollen on its inner face at half its length. Wide transverse bands cross each segment. The general shape and disposition of the markings will be apparent from Fig. 16. The last segment of the ♂ is flatly rounded, the tergum with a scattered fringe of a dozen hairs, longer externally; the sternum densely fringed with short hairs. The tergum of the last complete segment of the ♀ has the shape of a truncated cone, with rounded angles and flat hind margin, with about three hairs on each side. Beneath this projects a plate of somewhat similar shape, but narrower; densely fringed with hairs, which are short in the middle, but increase in size outwards, culminating in a dense pencil of about twenty strong hairs on either side. On the ventral side of this plate is a raised area, fringed with hairs and strongly denticulate, which may be part of the plate, but seems to be definitely sutured off from it. Whether these structures together represent the ninth sternum, or whether the posterior part represents a reduced tenth segment, I am unable to say without cutting sections. The genital aperture is covered by a broad transverse flap, carrying a fringe of short hairs, and, inside its margin, a pair of very stout hairs enclosing two short hairs and a patch of denticles. Lying between the seventh and eighth segments, close under the sterna, is a large transversely elongated bean-shaped ring of chitin, which may really be a ring, or may represent the thickened edge of a plate.

The appearance of the ♂ genitalia is shown in Fig. 16. I have not attempted to homologise the parts of this asymmetrical apparatus, the only easily recognisable features of which are the large unequal parameres and a very elongate 'preputial sac,' running through four segments, its wall densely covered with denticles, smaller in front and large behind.

Chaetotaxy of ♀. Head with two short hairs close together in front; two fair-sized hairs, one directed outwards and one backwards, with two or three smaller ones in front of the frontal cleft; internal to these a medium and a small hair overlying the base of the antenna; a few short hairs scattered over the dorsal surface; temporal angle with three long, one medium, and a number of short hairs, with a fringe along its ventral continuation, forming a dense comb-like group under the eye,

but sparser further forward; two minute prickles on hind border of temple, a hair inside the border, and two pairs on the occiput. Prothorax with five short spines on each shoulder; one behind each end of the inter-scapular bar; three spines, a hair, and a spine on each side anteriorly; and a row of ten hairs along the hind margin. Mesothorax with a pair of minute spines, one on each side of the middle line. Metathorax with a group of four spines inside the antero-lateral angle; a row of seven similar spines, projecting backwards, not outwards, on each lateral border; hind border with two hairs and a spine on each side, and a row of twelve hairs between them. Abdomen with a few spines and one to three hairs in each angle; the first segment with a fine hair inside each antero-lateral angle; all segments to the eighth with a row of alternating long and short hairs, the short hairs being in pairs in the median area. On the ventral surface there are two rows of hairs on each segment except the first. On the third and fourth segments the posterior row is broken at each side by a comb-like group of short spines, longer on the third than on the fourth segment.

Chaetotaxy of ♂. Differs only in the terminal segments of the abdomen, the arrangement for which has already been described.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head.....	0·33	0·64	0·33	0·64
Prothorax	0·27	0·47	0·27	0·49
Mesothorax	0·06	0·40	0·06	0·42
Metathorax	0·26	0·60	0·26	0·62
Abdomen .	1·62	0·86	1·54	0·84
Total length and greatest breadth	2·54	0·86	2·46	0·84

Numerous ♂♂, ♀♀, and ⊙⊙ from the varied lorikeet (*Ptilosclera versicolor*), blue-bellied lorikeet (*Trichoglossus novae-hollandiae*), and leatherhead (*Philemon corniculatus*), from Myall Lakes, New South Wales, April, 1912. Those found on the third host are obviously stragglers.

In Text-figure 1 the heads of *Menopon*, *Eomenopon*, and *Heterodoxus* are placed side by side for comparison. The ventral boundary of the antennary fossa, which is really a ventral continuation of the temple, is indicated by a dotted line. It will be seen that this fossa is most extensive in *Heterodoxus*, where it is floored by a plate with a ventral cleft corresponding to the dorsal cleft. In *Eomenopon* this ventral

flange is reduced, and the cleft has disappeared. The *Colpocephalum* condition can be reached from *Eomenopon* by cutting away that part of the forehead between the frontal cleft and the eye. Species in exactly this condition occur upon the cockatoos. It seems to me that the *Eomenopon* condition may have given origin to two divergent lines, one of which has become *Menopon*, the other *Colpocephalum*; and that possibly, as more forms are carefully examined, a more or less complete

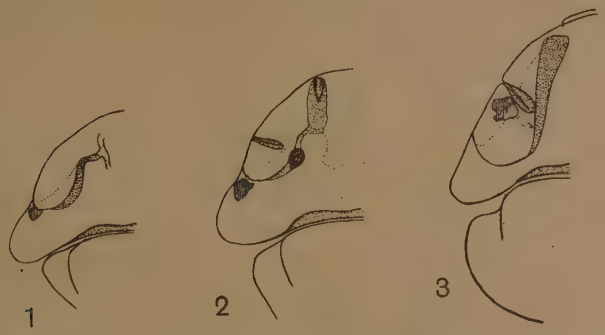

Fig. 1. Outlines of one side of the head of (1) *Menopon* sp., (2) *Eomenopon*, (3) *Heterodoxus*. The dotted line indicates the anterior ventral border of the antennary fossa.

phyletic series may be obtained. The relation of the Menoponidae to the Boopidae still remains an open question. Cumming's genus *Trimenopon* (1913, p. 40) may partly prove to bridge the gap; and, as far as head-structure goes, *Eomenopon* shows a somewhat intermediate condition. But the Boopidae possess some structures not found in any other Mallophaga, and their precise relationship cannot be established in the present state of our knowledge.

Genus *Machaerilaemus*, nov.

Two genera of Menoponidae have already been established chiefly on account of peculiar chitinous structures in the gular region, viz. *Ancistrona* Westwood (1874, p. 197), and *Pseudomenopon* Mjöberg (1910, p. 50), found upon petrels and rails respectively. To these I now add a third, from an Australian grassfinch, which bears a remarkable chitinous plate upon the throat. The genus may be characterised as follows:

Menoponidae with very broad head, more than twice as wide as long, bearing on the throat a large squarish chitinous plate, flanked by

two backwardly directed dagger-like processes, and with a large central sub-circular perforation; with a winged prothorax; meso- and metathorax distinct, sub-equal, and resembling abdominal segments; otherwise like *Menopon*.

Machaerilaemus latifrons, n. sp. Figs. 1–4.

Fig. 1 gives the general form of the ♀, from which the ♂ differs but little except in its smaller size, and in the usual sexual dimorphism of the hind end of the abdomen. The posterior segments of the ♂ are shown in Fig. 3.

The head is extremely broad in proportion to its length, being more than twice as wide as long, and affording the greatest width of the insect. The forepart is flatly rounded, the sides of the forehead being much swollen and abruptly rounded, and roofing the antennary fossa. The floor of this is formed by a forward continuation of the temple, which meets the inturned forehead at a point just behind the articulation of the palps; floor and roof being fused along their hind margins from this point to just in front of the eye, and enclosing a deep pocket in which the two terminal segments of the antenna can be completely hidden. The lens of the eye is fairly prominent, filling the angle between forehead and temple, its outline being continued dorsally towards the temporal angle. It carries a short spine. The pigment spot is roughly square. The temporal angles are acutely rounded, and the occiput flatly sinuous. On the ventral side (Fig. 2) the most remarkable feature is the plate upon the throat, the shape of which may be seen from the figure. The lateral spinous processes project freely, but the median part of the plate passes backwards under the anterior border of the prosternum. Six or seven hairs arise from the plate on each side. The terminal joint of the palps is the longest, and they show a fine annulation, giving a serrate outline in optical section, that I do not remember to have seen before in the group. The antennae are of the usual type.

The prothorax is winged, with an interscapular bar not quite reaching the scapulars (the intervening space being occupied by a small spine), and crossed by a median longitudinal crease for insertion of the dorsal prothoracic muscles. The claviculars are thick, and pass downwards, backwards, and inwards to fuse with the lateral angles of the prosternum. The *mesothorax* and *metathorax* are alike, and resemble abdominal segments. The thoracic sterna are shown in Fig. 2. The *coxae* of the

first pair are elongate, closely apposed at their hinder ends, and diverging forwards and outwards, the trochanters arising from their ventral faces a little nearer the anterior end. The coxae of the remaining two pairs are palette-shaped, with a notch on the inner margin. The *trochanters* are small and triangular; the *femurs* stout and strongly arched; the *tibiae* narrow proximally, and swollen distally, those of the third pair conspicuously long. The first joint of the *tarsus* (Fig. 4) is short, and bears a large flap-like appendage on the inner side. Mjöberg (1910, p. 213) refers to this structure as an onychium; but, whatever the precise meaning of this much abused term may be, it surely cannot be applied to a structure that has no connection at all with the grasping apparatus of the foot. The second joint of the tarsus is long, and bears on its inner face at about two-thirds of its length a small finger-like process, which collapses in balsam mounts. The flexing apparatus of the claws consists of a cross-striated triangular plate, the apex of which is connected with the flexor tendon, while from the base a ligamentous sheet passes to the claws. Each of the basal angles bears a hair.

The abdomen broadens very slightly, being widest at the fourth and fifth segments in the ♀, and at the fourth in the ♂, which tapers more rapidly posteriorly to the rounded ninth segment. The whole abdomen is yellowish brown, the pleura and a broad transverse band in each segment being darker brown. The last segment of the ♀ is rectangular dorsally, the vulva being broadly rounded on the ventral side, and the borders of both being densely fringed with short hairs.

Only one ♂ was available, and in it the genitalia are but lightly chitinised, so that it may not be quite mature. The general form of the apparatus will be clear from an examination of Fig. 3.

The chaetotaxy presents no features worthy of particular remark, and its general distribution is given in the various figures. The forehead shows five hairs and a prickle; the temporal angle three hairs and a spine, between which and the mid-line are a hair and a spine set in a common pustule, and a short hair. The prothorax has two spines, a long hair, and a spine on each side, and a series of eight hairs along the hind border. The mesothorax is distinguished from the metathorax and abdominal segments by the possession of a row of short spines on each lateral border. Meso- and meta-thorax, and the first seven abdominal segments, each have two to three hairs at the angles, and a row of ten along the hind margin. On the ventral surface of the head there are a pair of hairs in front of the gular plate, about six hairs on each

side of it, and four short hairs on the margin of the antennary fossa. The prosternum bears a group of about fifteen short spines. The first coxa has two spines anteriorly, and a group of hairs posteriorly. Meso- and metasternum each have a closely clustered group of hairs, and the second and third coxae have spinous anterior borders, and a cluster of hairs. The pleura of the abdomen bear on their ventral hind margin a row of a few spines; and each abdominal sternum carries two rows of hairs.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head	0·22	0·49	0·22	·57
Prothorax	0·14	0·32	0·15	·37
Mesothorax	0·07	0·36	0·07	·45
Metathorax	0·07	0·40	0·07	·47
Abdomen	0·57	0·47	0·72	·54
Total length and greatest breadth	1·07	0·49	1·23	·57

One ♂, possibly not quite mature, and seventeen ♀♀, from the Gouldian grassfinch (*Poephila gouldiae*), no locality given, N. C. Rothschild collection. The host is found in northern Australia, but is a popular aviary bird. The material belongs to the Entomological Museum of the University of Cambridge; and was handed me for description by Mr Hugh Scott, M.A., Curator in Entomology.

The affinities of the species are obscure. I know of no form with a gular plate of like character, or in any intermediate condition.

Sub-order Ischnocera.

Family Akidoproctidae, nov.

Mjöberg (1910, p. 96) has already foreshadowed the erection of a family to include the genera *Ornithobius* Denny and *Akidoproctus* Piaget. With these must certainly be included *Bothriometopus* Taschenberg. I have received from Mr G. F. Hill, Government Entomologist at Port Darwin, Northern Territory of Australia, a number of examples of a form from the pied goose (*Anseranas semipalmata*), for which I propose below a new genus *Heteroproctus*. This form links up to such a remarkable degree the three genera mentioned above, that I have no hesitation in establishing a family for the reception of the group of genera.

The family, for which I have taken the genus *Akidoproctus* as type (as taking the older *Ornithobius* of Denny might lead to confusion, the generic name *Ornithobia* having been used in Diptera) may be briefly diagnosed as: *Lipeurus*-like forms, large and elongate, without signate clypeus; with a notch of varying depth in the front margin of the head; with large antennae, alike or dimorphic, in front of the middle of the head; without trabeculae, or prominent trabecular angles; with swollen temples; with prothoracic stigmata prominent at the postero-lateral angle of the prothorax; and with long legs.

Some characters based on more minute detail might be added, but I have no material of *Bothriometopus*, and am unable to say, from available descriptions, whether it agrees in certain features common to the other genera. It is remarkable that, in spite of the compactness of the group, characters which are usually considered of generic importance are very unevenly distributed. The notch in front of the head is uniform in *Akidoproctus*, *Heteroproctus*, and *Bothriometopus*, but is very different in *Ornithobius*. The antennae are alike in *Akidoproctus*; almost alike to dimorphic in *Ornithobius*; markedly dimorphic in *Heteroproctus* and *Bothriometopus*. The last segments of the abdomen are conical in *Akidoproctus*, and in *Ornithobius* to a less degree; but in *Bothriometopus* the end of the abdomen is definitely two-pointed. In *Heteroproctus* the abdomen of the ♀ is pointed, while that of the ♂ ends in two broadly rounded lobes. The oesophageal sclerite is present in three genera, but totally absent in *Ornithobius*. The very remarkable spinous genital plate of the ♀ *Heteroproctus* (Fig. 8) also occurs in *Ornithobius* and *Akidoproctus*. The subsidiary transverse bands on the posterior abdominal segments of the ♂ *Heteroproctus* are found also in *Bothriometopus*.

The following key will serve to differentiate the genera of the family:

A.	Anterior emargination crescentic	*Ornithobius*
AA.	Anterior emargination oblong.	
B.	Antennae alike in the sexes	*Akidoproctus*
BB.	Antennae differing in the sexes.	
C.	End of abdomen bilobed in both sexes	*Bothriometopus*
CC.	Abdomen bilobed in ♂, conical in ♀	*Heteroproctus*

Genus *Heteroproctus*, nov.

Akidoproctidae of more than average size (3–4 mm.), and elongate form. Head with deep squarish emargination in front; trabecular angle rounded, and with a ridge running parallel to its lateral border dorsally, giving a double outline; antenna of ♂ with an appendage on the third segment. Prothorax with prominent stigmata at postero-lateral angles; metathorax wider than the head, widest posteriorly. Abdomen of nine segments, the eighth of which is obviously of a double nature; parallel-sided, tapering rapidly from the seventh segment to an acuminate point in the ♀, but only gradually in the ♂ to the much wider bilobed ninth segment; bands differing in the sexes. ♂ genitalia with large parameres with bluntly rounded apices, the remainder of the apparatus being plate-like.

Heteroproctus hilli, n. sp. Figs. 8–11.

Reference to the figures of ♂ and ♀ will make clear the general form. The ♂ is smaller than the ♀, and the sexes differ in the form of the antennae, of the posterior end of the abdomen, and of the abdominal markings. The two latter differences affect the chaetotaxy.

The head is narrow in front, where it ends in two rounded forcipate lobes, separated by the emargination, which is wider posteriorly, and extends about half way to a line joining the antennae; the lateral margins of the forehead concave, widening to the trabecular angle, which is bluntly rounded, and has the double character alluded to above; behind this angle the head is distinctly constricted; the eye is not prominent, the pigment fleck being small and roughly triangular; from the eye the temples swell out evenly, the greatest width being a little in front of half the distance from eyes to occiput; width at temporal angles about that at eyes, angles rounded; occiput sinuous, with a median and two lateral concavities, separated by two slight convexities. Antenna of ♂ large, first article as long as second and third together, cylindrical, narrower proximally; second article two-thirds first, narrower; third article shorter, truncated, with an appendage; fourth and fifth sub-equal, diverging almost at right angles; the terminal three articles distinctly darker than the basal two. Antenna of ♀ with first article shorter, thicker, and lighter in colour than second; terminal three forming a decreasing series, all darker in colour than second; final two forming an angle with remainder. Sensory grooves elongate, one on each of the two terminal articles, on the posterior border, that of the

fourth article placed distally at three-quarters of the length, that of the fifth a little proximal of half the length. In colour, a little more than a third of the head on either side is dark translucent brown, leaving a median area yellowish white except for the narrow chitinous hind border of the emargination, a curved chitinous piece in front of the mandibles, which may represent a labrum, the mandibles themselves, the oesophageal sclerite, and a faint elongated triangular plate on the ventral surface, for which I would propose the term *gular plate* in place of Kellogg's *occipital signature*. The heavier markings of the head consist of two fine blackish bands running from the posterior mandibular articulation to the occiput, just in front of which they send inwards slight projections, and continuous round the temporal margins to the eyes; and of two short bands which, commencing just behind and outside the anterior mandibular articulation, diverge outwards to the margins of the forehead in front of the trabecular angles, sending internal branches round the inner margins of the dark chitin of the forehead, which run forward to support the forcipate lobes. Just before these latter reach the level of the hind border of the emargination, they exhibit a sharp curl outwards and inwards again, which is too small to appear in the figures, but which is obviously the homologue of the much more prominent structure of the same nature found in *Ornithobius*.

The occipital apodeme apparatus is a little complex, and comprises a black crescentic piece supporting the median convexity of the occiput, which has the appearance of being poised upon a black triangular projection of the prothorax, while a pair of apodemes of the usual convergent type project backwards into the prothorax.

The prothorax is alike in the sexes, rectangular, with the anterior angles truncated, the posterior square, with projecting, crater-like stigmata, and the hind margin slightly convex. It is dark brown, with a light median space, the lateral margins being blackish brown. The *metathorax* is almost twice as wide as the prothorax, with forward projecting antero-lateral angles, swollen sides, widest posteriorly, with truncated postero-lateral angles, and a hind margin somewhat convex on the abdomen. It also is divided by a median uncoloured line, which does not quite reach the hind border in the ♀; and is darker at the antero-lateral angles and along the lateral margins. Between the metathorax and the first abdominal segment appears an angular projection, which is part of the endo-sternal apparatus in connection with the acetabulum of the third coxa.

The abdomen of the ♂ is composed of nine apparent segments, of which the eighth shows very obviously that it is composed of two fused segments. It is parallel-sided to the fifth segment, whence it tapers slightly, the convergence becoming emphasised from the distal half of the double eighth segment. The arrangement of the chitinous markings will be best understood by reference to Fig. 10. The light spots found anteriorly on the second to the seventh segments of the ♀ only appear on the second and third segments of the ♂. There is an uncoloured median space through the first three segments. The third segment has a subsidiary transverse band, divided into two isolated blotches by this space, behind each of which is a small dark bar on the hind margin of the tergum. The transverse and subsidiary bands of the next three segments are entire, the subsidiary bands showing, however, a median anterior notch. The posterior border of the subsidiary band of the sixth segment is indented on either side for the pustule of a hair. Similar small bars, somewhat lighter in colour, are present on the hind margin of these three segments, those of the sixth segment being shorter than the rest. The transverse band of the seventh segment is entire, its posterior margin being indented by four pustules on either side. The eighth segment is more or less parallel-sided to a third of its length, where a group of pustulate hairs is situate upon the margin; after which the sides converge rapidly. A lighter coloured area extends across the segment between the two groups of pustulated hairs. The postero-lateral angles are produced slightly backwards. The terminal segment is composed of two dark rounded lobes, separated by a very narrow uncoloured line.

The abdomen of the ♀ has its sides sub-parallel to the seventh segment, the last two tapering abruptly. The first segment resembles that of the ♂. The next six are alike in character, each bearing two squarish lateral blotches, separated by a wide median space, occupied by a third rectangular blotch, lighter in colour and softer in outline. Towards each antero-lateral angle is a small light-coloured spot, a perforation in the heavy chitin of the pleura, from the hind border of which an irregular dark band runs towards the stigma. The eighth segment is almost uniformly coloured, but shows indications of median longitudinal and transverse division. The ninth segment forms a dark equilateral triangle, bisected by a narrow uncoloured line.

The ♂ genitalia have large parameres, which lie with their ends crossed in the position of retraction, the tips being broadly rounded. The basal plate is very weakly chitinised, only the distal part of its

lateral margins being at all prominent. The form of the apparatus is indicated in Fig. 9. The genital plate of the ♀, as shown in Fig. 8, is shaped like an arrow-head with broken tip, each barb being set with a row of about twelve stout spines.

The chaetotaxy of the head agrees very remarkably with that of *Ornithobius fuscus*. There are a number of short hairs on the forehead, two more on each side in the ♂ than in the ♀; a short hair in the eye; five on the temple, of which the second is a little, and the fourth considerably, longer than the rest; and one short prickle on the hind margin close to the angle. The prothorax carries a pair of hairs on the posterior margin, close to the stigmata. The metathorax has two lateral hairs in front of the posterior angle, and three, set in a single large pustule, inside the hind margin close to the angle. In the ♂ abdomen, each segment save the last has a short backwardly directed spinous hair at the posterior angle; the anterior segments have, in addition, one or two softer hairs; the sixth segment has two pustulated hairs partly inserted into the subsidiary transverse band; the seventh segment has four pustulated hairs on either side; the eighth segment á long and a short hair on either side; the ninth segment, three short hairs. Ventrally, there is a group of about eight hairs in the middle of the first sternum, a median pair on the second to the fifth, flanked by minute prickles, two pairs of prickles only on the sixth, and a group of about a dozen short hairs on the latter half of the eighth. The genital opening is ventral, the posterior margin of the sternum being notched in the middle, and bearing an evenly spaced fringe of about a dozen short hairs. In the ♀ the anterior segments are much as in the ♂. The seventh has two long hairs on the lateral border, in front of the angle, and three pustulated hairs on either side on the hind margin. The eighth has a long hair and a prickle at a third of its length laterally, and three pairs projecting from the ventral surface. The ninth has a short lateral prickle.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head	0·91	0·58	0·87	0·59
Prothorax	0·35	0·42	0·35	0·42
Metathorax	0·35	0·67	0·40	0·71
Abdomen	1·97	0·64	2·42	0·71
Total length and greatest breadth	3·58	0·67	4·04	0·71

Seven ♂♂, 4 ♀♀, and 6 ⊙⊙, from the pied goose (*Anseranas semipalmata*), Koolpinyah, Northern Territory of Australia, July, 1913, G. F. Hill.

It is somewhat significant that this parasite, coming from a host with the generic name of *Anseranas*, should link up in so marked a fashion the genus *Akidoproctus* found on ducks with the genus *Ornithobius* found on geese and swans. Still more important is the fact that it connects with these genera the previously somewhat isolated *Bothriometopus* from *Palamedea*, and thus points to a confirmation of the anserine affinities of the Palamedeidae.

Family Goniodidae.

Genus *Austrogoniodes*, nov.

The Mallophaga of the above family hitherto described from penguins are three in number, viz., *Goniocotes bifasciatus* Piaget (1885, p. 47) from *Spheniscus demersus*, *G. waterstoni* Cummings (1914, p. 173) from *Eudyptula minor*, and *Goniodes brevipes* Giebel (1878, p. 254) from *Aptenodytes longirostris*. I propose to describe presently a new species from *Eudyptes sclateri*, and I have in hand half a dozen other species, which will be described in the zoological results of the Australasian Antarctic Expedition. I find that these species form a compact group, with certain easily recognisable features in common, for which I now propose generic rank.

The characters upon which I base the genus are not of striking morphological significance, but they are sufficient to render the species included recognisable at a glance. The chief is the head-shape, the temples being greatly swollen, and produced far back alongside the prothorax. The anterior temporal 'angle' is never really angular. In most species it is only a broadly rounded swelling, though in one or two it becomes obtusely rounded, and more or less angular. The posterior temporal angle is produced backwards into an acute point, reaching to at least half the length of the prothorax, and continued by a stiff spine back on to the metathorax. The result is a head-shape which, however much it may vary in detail among the members of the genus, differs from that of any other Goniodidae. The second character is the shortness of the legs, particularly of the tibiae, which are, in some species, as broad as long, and which are always armed with heavy conical processes, not well enough chitinised to be called spines. Apart from these, it may be noted that the ♂ abdomen always ends in a

rounded heavily chitinous plate, to which is attached a great part of the strong musculature controlling the copulatory apparatus; that the end of the ♀ abdomen is broader, and lightly to deeply notched in the middle; that the metathorax comes far back on to the abdomen; and that its postero-lateral margins are usually continued beyond the sutural line of the hind margin, in a way that will appear later in the figures. The antennae are in some species alike, in others widely dimorphic; and show, in general, a tendency to reduction of the number of articles by fusion, so that, in some species, only three are present in the adult. In two species the ♂ antenna bears an appendage.

These antennal differences, which have been used in the past to separate genera, I am now forced to consider, of little importance. It was first pointed out to me by Mr J. D. Waterston that copulatory appendages on the antennae have arisen quite independently in several groups. My own observations have amply confirmed this view, so I make no attempt to split the present group on antennal differences. This will also explain why I have, in compounding the generic name, used *Goniodes* instead of *Goniocotes*. It may be possible to establish the latter genus on other grounds, but it is not justifiable to separate it from *Goniodes* on antennae alone. As type of *Austrogoniodes* I designate *Goniocotes waterstoni* Cummings.

Austrogoniodes strutheus, n. sp. Fig. 15.

The head is obtusely rounded in front, and not flatly so, as in most Goniodidae. The side of the forehead is continued ventral to the antenna into a prominent trabecular angle, which reaches almost to the end of the first antennal article. The eye is slightly prominent, with a minute conical spine, and without a pigment spot, though all the remaining species have pigmented eyes. Behind the eye, the temple swells out broadly to a greatest width a little in front of half its length; then sweeps inwards and backwards, with a concave outline, to form an acuminate process at the side of the prothorax, reaching to more than half its length, and continued by a stout spinous hair which reaches to the metathoracic angle. The occiput is flatly convex on the prothorax, then curves outwards and backwards to form the inner margin of the acuminate process. The markings of the head are conspicuous (Text-fig. 2, 1). Two large triangular black blotches occur on the occiput, one in front of each lateral angle of the prothorax. Each of these is continued externally as a narrow brown band reaching the base of the temporal spine; internally as a narrow band along the median occipital

margin; and anteriorly as a broad ill-defined brown band reaching to the posterior mandibular articulation, and then spreading broadly to embrace the eye and the base of the antennal band. The latter is deep brown, begins external to the anterior mandibular articulation, runs to the frontal margin in front of the antenna, and turns along the anterior border of the head to meet that of the other side, becoming narrower as it goes forward, except for a short length in the middle of the front which is biconvex, and affords one means of distinguishing this species from most of its congeners. From between the antenna and the eye a

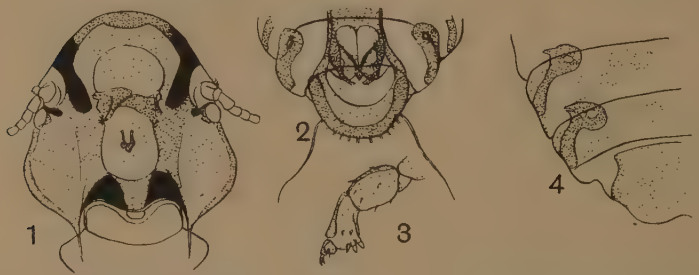

Fig. 2. *Austrogoniodes strutheus*: (1) head of ♂; (2) last segments of abdomen, ♂; (3) third left leg; (4) last segments of abdomen, ♀, showing the bird-like pleura.

short band runs inwards, not quite meeting the base of the antennal band. From behind the eye a very narrow band edges the temporal margin to the base of the spine. The antennae are alike in the sexes, the first article being a trifle more swollen in the ♂. The basal article is longest; the second narrower and shorter; the third and fourth subequal, and shorter still; the fifth shortest. The sinus is large and semicircular, roofed dorsally by a transparent membrane, and partly covered ventrally by the trabecular angle, and a slight forward projection of the posterior angle.

The prothorax is more or less rectangular, its antero-lateral angles rounded, its hind border convex on the metathorax. The pronotum bears an hour-glass-shaped transverse band, darker postero-laterally, and more deeply emarginate in front; the space thus left being filled by a small oval blotch. (This last has, in Giebel's figure of *Goniodes brevipes* (1878, pl. xiv., fig. 19), been included within the occipital border.) The *metathorax* is as broad as the head immediately in front of the eyes. The postero-lateral borders are carried back on to the abdomen as far as the anterior border of the second segment; the hind margin being

straight, and anterior to their terminations. It carries a dark band along the antero-lateral border, and otherwise is uniformly coloured, except that it is slightly lighter along the postero-lateral borders, and that the coloration stops short of the hind margin. The *legs* are short, thick, and heavily chitinised, the tibia bearing distally four stout conical processes, two of them pedunculated.

The abdomen is of eight apparent segments, widest at the second and third, thence tapering slightly to the seventh, which is followed in the ♀ by the broadly rounded, slightly emarginated, eighth; while in the ♂ that segment is heavily chitinous, and semicircular. The details of the transverse bands and pleural markings are shown in Fig. 15. The pleural bands, particularly in the ♀ and towards the posterior end (Text-fig. 2. 4), bear a ridiculous resemblance to a row of bird's heads, poised upon long necks, which has suggested the specific name.

The genital plate of the ♀ is a flap hinged laterally, concave in the middle, and fringed with short hairs, which increase in size on either side, culminating in a row of a dozen stout curved hairs. The ♂ genitalia, shown in Text-fig. 2. 2, are complex, and differ considerably from those of *A. waterstoni* and other members of the genus.

Chaetotaxy of ♀: the forehead shows eight extremely small evenly spaced spines; similar spines are scattered over the surface of the head; two similar spines between antenna and greatest width, at which point a similar spine and a longer stouter one occur, followed by another short spine round the 'angle.' Prothorax with a pair of small spines anteriorly; and a short hair on the hind margin towards each postero-lateral angle. Metathorax with a very short spine in front of, one at, and three, alternating with hairs, behind the angle; two hairs at the angle, two on the postero-lateral margin, and six along the hind border, with a pair posterior to them. Legs strongly beset with short spines, in addition to the spinous processes mentioned above. Each anterior abdominal segment with a row of about six hairs in the median area, flanked by a pair of minute spines on a line with the inner ends of the pleural bands; first segment with a couple of minute spines at the angle, remainder with 2–3 hairs in addition; eighth segment with three hairs on either side, and a pair of spines on the hind border. On the ventral side, the sternal region is free from hairs, except for a couple on the hind border of the metasternum; but each abdominal segment bears a row of fine hairs.

Chaetotaxy of ♂: differs in having a fair-sized hair in place of the spine just behind the greatest width of the temple; in having a row of

five hairs anteriorly on either side of the bilobed tergum of the eighth segment; and in having a row of about twelve channelled hairs round the much-produced sternum of the same segment, which forms the end of the abdomen.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head to middle of occiput	·38	·47	·40	·54
Head to line of posterior angles	·50	—	·48	—
Prothorax	·10	·22	·13	·23
Metathorax	·14	·34	·15	·39
Abdomen from line of anterior angles	·62	·45	·89	·71
Total length and greatest breadth	1·16	·47	1·51	·71

Numerous ♂♂ and ♀♀ from *Eudyptes sclateri*, N. C. Rothschild collection, no locality given. Probably from one of the southern islands of New Zealand. Given me for description by Mr Hugh Scott, M.A., Curator in Entomology.

This species would appear to be closest to *A. bifasciatus* of Piaget, from which it differs in its smaller size; in the chaetotaxy of the abdomen; in the concave vulva; and in the hind end of the ♂ abdomen, the heavy chitinous border of which is produced much further forwards and inwards. It is easily distinguished from *A. brevipes* Giebel and *A. waterstoni* Cummings by the antenna, apart from other differences.

Family ————————?

Genus *Psittaconirmus*, nov.

This genus is established for the reception of a parasite of Australian lorikeets, which shows, in conjunction with a general nirmoid form, considerable sexual dimorphism, involving the antennae, and a peculiar forcipate clypeal front.

According to the present criteria of classification, this genus should be included in the Lipeuridae. But I have good reasons for believing that it would be quite wrongly placed. To begin with, it is indubitably closely related to other forms from Australian parrots, which must at present be placed in the genus *Degeeriella*. And secondly, its own structure is, apart from the antennae, that of *Degeeriella* and not *Lipeurus*. In the form of the head, and particularly in the structure of the occipital apodemes and the prothoracic skeleton, it agrees with a

group within the genus *Degeeriella* which characterises parrots and hawks. Piaget (1880, p. 300) has certainly included some of these parrot infesting forms in the genus *Lipeurus*; but, in the case of *L. circumfasciatus*, the tubercle on the third article of the ♂ antenna, which is presumably his justification for the position in which he places the insect, is a sense organ, and not a clasping appendage. Pending a revision of the classification, I prefer to hold over any more precise statement as to the position of *Psittaconirmus*. The genus may be diagnosed as follows:

Ischnocera of smallish size (less than 2 mm.) with elongate nirmoid form; head circumfasciate, without signate clypeus, broken in front by an oval emargination, across which the points of the frontal margin overlap; with definite weak trabeculae; third article of ♂ antenna with an appendage; transverse bands of abdomen continuous in the ♂, interrupted in the ♀; hind end of abdomen rounded in the ♂, bifid in the ♀. On Australian Loriidae.

Psittaconirmus australis, n. sp. Figs. 7, 12–14.

Head broad in front, sides of the forehead diverging slightly to the trabeculae, divergence continuing to a greatest width a little in front of the occiput; temporal angles broadly rounded; occiput with a slight convexity. In front is a small oval emargination, closed anteriorly by the acute overlapping tips of the frontal margin. Trabeculae weak, acute, as long as the first antennal article of the ♀. Antennae differing in the sexes; ♂ with first article as long as the distal four together, narrower proximally; second article a third of first; third shorter, with an appendage; fourth shorter than fifth; ♀ filiform, first article shorter and broader than second; third and fourth shorter and sub-equal; fifth longer. Antennal bands, starting from an enlargement at the base of the antenna, run outwards and then forwards round the margin of the head, gradually reducing in thickness to end in the overlapping acuminate points. Internal bands run forwards from the anterior mandibular articulation, turning inwards, then forwards again, to end in rounded enlargements on either side behind the emargination; the latter bound behind by a curved chitinous band. Temporal bands are continuous from eye round occiput; occipital bands hardly exist. The oesophageal sclerite is well marked. The eye is fairly prominent, with a hair and an elongated pigment spot.

Prothorax short and much narrower than the head; narrower in front, with dark lateral borders and a median uncoloured space. *Metathorax*

narrow in front, widening rapidly posteriorly, with hind angles rounded, and margin slightly convex; with dark lateral bands, thickening at the antero-lateral angles. *Legs* elongate.

Abdomen of ♂ with sub-parallel sides anteriorly, tapering gradually from the fifth segment to the rounded ninth. Pleura of first to sixth segments of strong translucent brown, continued forwards and inwards into the segment in front, and with a median inwardly directed rounded enlargement; of segments seven and eight narrower; all eight segments with a broad light-coloured transverse band. Terminal segment rounded, with tergum only faintly chitinous. Abdomen of ♀ broader, widening evenly to the fourth segment, whence it tapers gradually to the bifid ninth. Pleura as in the ♂; but the transverse bands of the first seven segments have a broad median interruption. The hind border of the eighth segment is the shape of an inverted V; and its transverse band seems to be continuous. The ninth segment has the form of two narrow triangular lobes, each fringed with a dense pencil of hairs projecting from the ventral side.

The material at my disposal has not been sufficiently well preserved to allow of a satisfactory description of the genitalia. In the ♂, the apparatus is complex. The basal plate reaches forward to the anterior border of the fifth segment, and its lateral margins become heavily chitinised as it passes backwards. The parameres are straight, with their tips (Fig. 7) truncated, and bearing a longish hair. But the median part of the apparatus is not in fit condition for description.

Chaetotaxy of ♀. Forehead with five extremely fine small hairs, the fifth just in front of the trabecula; a spine in the eye, and three along the lateral temporal margin; a fairly long hair at the angle; two spines between this and the prothorax on the hind margin, and a pair of spines inside the occipital border. Prothorax with a pair of short hairs on the hind margin. Metathoracic angle with, from without inwards, a spine, a hair, a row of three pustulated hairs, followed by a second similar row. Abdomen with one or two hairs at the angle, and a pair of hairs on the hind border, of each of the first seven segments. Segments five to seven have an additional pair of hairs laterally on the hind border. Eighth segment with four hairs; ninth terminated on either side by a brush of hairs. The ♂ differs only at the posterior end of the abdomen, where the square flap of the eighth segment, covering the genital opening, carries a row of ten short hairs, and the ninth segment has six or seven scattered hairs on each side.

Measurements in millimetres.

	♂		♀	
	Length	Breadth	Length	Breadth
Head	0·39	0·27	0·42	0·32
Prothorax	0·10	0·20	0·10	0·22
Metathorax .	0·17	0·32	0·18	0·37
Abdomen	0·69	0·35	1·03	0·50
Total length and greatest breadth	1·35	0·35	1·73	0·50

One ♂ and three ♀♀ from the purple-crowned lorikeet (*Glossopsittacus porphyrocephalus*), Bow River, Western Australia, 30 October 1912, S. W. Jackson.

Fig. 3. Head and prothorax of *Psittaconirmus* ♀.

Two ♀♀, one of which is immature, from the blue-bellied lorikeet (*Trichoglossus novae-hollandiae*), Myall River, New South Wales, I provisionally assign to this species. These show some differences, which may be real, or may be due to the marked difference in the state of preservation. I figure the adult ♀ (Fig. 14), as well as the head, and the occipital apodemes (Text-fig. 3). The main differences lie in the darker coloration of the pleura and all lateral bands; the better defined transverse bands of the abdomen, with stigmata prominent in light-coloured areas; the inner row on the metathoracic border containing two, not three, hairs; and the pencils of hairs on the ventral surface of the ninth segment being so short as not to project beyond the borders of the segment. The measurements of this ♀ are also slightly larger, as the following table shows:

Measurements in millimetres.

	♀	
	Length	Breadth
Head	0·44	0·35
Prothorax	0·11	0·23
Metathorax	0·20	0·39
Abdomen	1·11	0·47
Total length and greatest breadth	1·86	0·47

The species dealt with in this paper have all been described from ovigerous females, and males with the genitalia chitinised. All figures have been drawn with the aid of a *camera lucida*. The types will be deposited in the Australian Museum, Sydney, New South Wales; and, as far as the material available allows, co-types will be placed in the British Museum, and in the Entomological Museum of the University of Cambridge.

LIST OF HOSTS WITH PARASITES.

Eudyptes sclateri	*Austrogoniodes strutheus.*
Anseranas semipalmata	*Heteroproctus hilli.*
Trichoglossus novae-hollandiae	*Eomenopon denticulatus.*
	Psittaconirmus australis.
Glossopsittacus porphyrocephalus	*Psittaconirmus australis.*
Ptilosclera versicolor	*Eomenopon denticulatus.*
Philemon corniculatus	*Eomenopon denticulatus.*
Poephila mirabilis	*Machaerilaemus latifrons.*

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DESCRIPTION OF PLATES XXVI AND XXVII.

PLATE XXVI.

Fig. 1. *Machaerilaemus latifrons*, ♀.
Fig. 2. „ „ ventral surface of head and thorax.
Fig. 3. „ „ last segments of ♂.
Fig. 4. „ „ third tarsus.
Fig. 5. *Eomenopon denticulatus*, ventral surface of head.
Fig. 6. „ „ abdomen of ♀, ventral.
Fig. 7. *Psittaconirmus australis*, tip of right paramere, ♂.
Fig. 8. *Heteroproctus hilli*, end of abdomen, ♀.
Fig. 9. „ „ end of abdomen, ♂.

PLATE XXVII.

Fig. 10. *Heteroproctus hilli*, ♂.
Fig. 11. „ „ ♀.
Fig. 12. *Psittaconirmus australis*, ♀.
Fig. 13. „ „ ♂.
Fig. 14. „ „ ? ♀.
Fig. 15. *Austrogoniodes strutheus*, ♀.
Fig. 16. *Eomenopon denticulatus*, ♂.

OBSERVATIONS ON THE BIOLOGY OF IXODIDAE.

PART II. DEALING WITH

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By GEORGE H. F. NUTTALL, F.R.S.

(*From the Quick Laboratory, University of Cambridge.*)

Introduction.

The observations herein recorded are in continuation of those published in Part I (*Parasitology*, VI. 68–118, April 1913) to which the reader is referred for general information as to the methods employed in these investigations.

In the following pages will be found complete raising notes relating to five species: *Amblyomma hebraeum*, *Dermacentor reticulatus*, *D. venustus*, *Rhipicephalus bursa* and *R. sanguineus*, all of which are important carriers of disease. Less full are the accounts relating to

[1] This name is still *sub judice*.

the four species *Amblyomma variegatum*, *Haemaphysalis cinnabarina*, *H. concinna* and *H. inermis*, whilst only short notes are given which bear on the two species *Amblyomma splendidum* and *Hyalomma syriacum*. The notes on *Hyalomma aegyptium*, *Ixodes putus* and *Rhipicephalus appendiculatus* supplement those already published in Part I.

I am much indebted to Dr E. Brumpt of Paris for the opportunity of studying his notes relating to *Haemaphysalis concinna* and *H. inermis*, species of whose life-histories nothing has hitherto been known and which Dr Brumpt has been the first to raise successfully. The life-history of *H. inermis* is unique among the Ixodoidea.

When dealing with large numbers of immature stages no attempt was made to determine more than the minimum period occupied in metamorphosis in each lot, it being recognized that certain individuals may undergo development more slowly than do others. The length of time the various stages feed upon the host is subject to individual variation under what appear to be identical conditions, moreover, a marked influence upon the period of parasitism is exerted by the blood supply which the tick is able to secure from the host at the point of attachment; a poor blood supply lengthens the period of parasitism materially. It must be remembered that ticks do not always feed immediately after they are placed upon the host and that this delayed feeding may easily lead to misconceptions regarding the length of the feeding period, consequently minimum periods are more accurate ones upon which to base conclusions.

I have sought, throughout this paper, to give full credit to the work of other authors who have studied the biology of some of the species to which these notes relate. With a few notable exceptions the data supplied in the literature on ticks are exceedingly meagre, and it appears desirable to have more precise and detailed information supplied in the future by those who are in a position to pursue these studies.

AMBLYOMMA HEBRAEUM.

The ticks used for the raising experiments about to be described were nearly all descended from two fully gorged and fecundated females (N. 1732) received in Cambridge on 20. VII. 1912, from Mr C. P. Lounsbury, Chief of the Division of Entomology, Department of Agriculture, Pretoria, South Africa. A few earlier observations relate to ticks (N. x) received in 1905 from the same source in connection with investigations on the disease known as Heartwater.

It is worthy of note that this tick has been much less prevalent on stock in South Africa of recent years in consequence of the cattle there being subject to systematic dipping operations. Thus, the representative of Messrs Wm. Cooper and Nephews, writing to me from East London in October, 1912, states that their farm is practically free from *A. hebraeum*, adding "where we used to lose 90 % of our calves from Heartwater we now lose none, that is to say our losses in the last two years from this cause have been one calf"; they rear about 150 animals a year upon the farm. Similar reports have reached me from other quarters, and I had difficulty in obtaining living ticks in 1912 for these raising experiments.

The only author who has studied the biology of *A. hebraeum* is C. P. Lounsbury. The observations recorded in his papers (Lounsbury (1) 1899, 16 pp.; (2) 1900, pp. 21 *et seq.*; (3) 1900 a, pp. 41–44; (4) 1902, pp. 47, 66–69; (5) 1904, pp. 15–20[1]) have been fully confirmed. His records are very brief, so that it is possible to incorporate them wholly[2] in brackets in the following pages. Lounsbury outlined the main features of the life-history of the species and deserves great credit especially for having demonstrated that *A. hebraeum* conveys the disease Heartwater to cattle, sheep and goats.

The time A. hebraeum *remains upon the host.*

Larvae

Lot	Host	Date when put on host	Host maintained at average temp. of	Number of gorged larvae collected on successive days	Remarks
N. 1732	Ram	14. I. 1913	4° C.	6 on day 5	[Lounsbury
				106 „ 6	(1) states that
				292 „ 7	the larvae stay
				453 „ 8	4–9, but gener-
				312 „ 9	ally 6–7 days
				183 „ 10	on the host.]
				96 „ 11	
				50 „ 12	
				24 „ 13	
				12 „ 14	
				6 „ 15	
				1 „ 16	
				2 „ 17	
				1 „ 18	
				1544	

[1] See our *Bibliography of the Ixodoidea*, Cambridge, 1911; Lounsbury's papers are referred to by the numbers (1–5) respectively in these notes.

[2] The part played in pathology is excluded.

Larvae.

Lot	Host	Date when put on host	Host maintained at average temp. of	Number of gorged larvae collected on successive days
N. 1732	Ram	20. II. 1913	3·3° C.	3 on day 5
				547 „ 6
				610 „ 7
				812 „ 8
				442 „ 9
				249 „ 10
				404 „ 11
				232 „ 12
				112 „ 13
				47 „ 14
				50 „ 15
				17 „ 16
				6 „ 17
				2 „ 19
				3533
N. x	Hedgehog	20. I. 1906	ca. 12° C.	13 on day 27
				71 „ 28
				8 „ 31
				80 „ 32
				120 „ 33
				160 „ 35
				50 „ 42
				502
N. x	Hedgehog	17. IX. 1906	ca. 18° C.	13 on day 12
				316 „ 13–14
				95 „ 15
				88 „ 16
				49 „ 17
				561

To determine if the gorged larvae abandon the host more freely by day than by night, a number of unfed larvae (N. 1732) were placed on a ram's scrotum on 20. II. 1913. They were afterwards collected in two lots: (*a*) those falling off by night (10 p.m. to 10 a.m.) and (*b*) those falling off by day (10 a.m. to 10 p.m.) on successive days:

Night collection		Day collection	
25–26. II. gathered	192	26. II. gathered	355
26–27. „	148	27. „	462
27–28. „	191	28. „	621
28. II.–1. III „	180	1. III. „	262
	711		1700

Nymphs.

Lot	Host	Date when ticks put on host	Host maintained at average temp. of	Number of gorged ticks collected on successive days	Remarks
N. 1732	Ram	7. III. 1913	6·5 C.	4 on day 5 17 „ 6 3 „ 7 — 24	The nymphs had previously fasted 31 days. They were put on ram's scrotum in a sack.
N. 1732	Ram	2. IV. 1913	8·3° C.	78 on day 5 205 „ 6 138 „ 7 19 „ 8 35 „ 9 13 „ 10 19 „ 11 18 „ 12 6 „ 13 4 „ 14 3 „ 15 1 „ 16 5 „ 17 2 „ 18 — 546	The nymphs had previously fasted 22 days. They were put on ram's scrotum in a sack.
N. 1732	Calf	17. XI. 1913	13·3° C.	217 on day 4 810 „ 5 530 „ 6 160 „ 7 76 „ 8 30 „ 9 20 „ 10 22 „ 11 6 „ 12 — 1871	The nymphs had previously fasted 38 days. They were put on calf's ear in a sack. [Note: Lounsbury (1) states that nymphs stay 4½–8 days upon the host.]
N. x	Goat	5. VI. 1906	ca. 21° C.	all on days 6–7	
N. x	Goat	22. IX. 1906	ca. 14° C.	1 on day 13 4 „ 14–19 1 „ 21 9 „ 22 — 15	

Adults.

Lot	Host	Date when ticks put on host	Host maintained at average temp. of	Number of gorged ticks collected on successive days	Remarks
		(*Females*)			
N. 1732	Calf	27. IV. 1913	19° C.	2 on day 10	3 ♂ had been placed on calf's ear 2 days before the 3 ♀.
				1 „ 12	
„	„	13. V.	20° C.	1 on day 6	ditto.
				2 „ 7	
„	„	21. V.	22° C.	2 on day 6	ditto.
				1 „ 8	
„	„	30. V.	20° C.	1 on day 8	ditto.
„	„	11. VII.	20° C.	2 on day 7	20 ♂ had been placed on calf's ear 4 days before 20 ♀.
				5 „ 8	
				3 „ 9	
				2 „ 10	
„	„	28. VII.	22·5° C.	5 on day 7	16 ♂ had been placed on ear before 16 ♀.
„	„	14. X.	14·5 °C.	7 on day 8	7 ♂ put on before 7 ♀.
„	„	24. X.	14·1° C.	1 on day 7	12 ♂ put on before 12 ♀.
				7 „ 8	
				1 „ 9	
				1 „ 10	
„	„	17. XI.	10° C.	4 on day 9	6 ♂ put on before 6 ♀.
				2 „ 11	
			Total	50 ♀	
		(*Males*)			
N. 1732	Calf	25. IV. 1913	put on 3 ♂	1 on day 41	was found wandering in ear sack.
				1 „ 152	found still attached and alive.
				1 „ 161	found loose and dead in sack.
„	„	8. VII. 1913	put on 20 ♂	2 on day 65	found loose and dead in sack.
				1 „ 140	found loose and dead in sack.
				1 „ 145	found loose and dying in sack.
				1 „ 163	found wandering in sack.
				1 „ 225	found wandering in sack.
				1 „ 267	found still attached and lively when the host died of East Coast Fever (conveyed by *Rhipicephalus appendiculatus*)
			Total	10 ♂	

Note :—Lounsbury (1, 2, 4) states that the ♀ stays 6½–10–12 days upon the host if she has found a mate from the start; she does not remain attached for a longer period in winter than in summer. The ♀ gorges most rapidly on cattle (8 days), less quickly on goats and sheep (9–10 days). When attached to the udder and belly of a goat they feed more rapidly than they do upon the legs and feet where they may at times cling as long as 25 days. If the ♂ is not virile the ♀ may remain attached for some weeks. He found (1, 2, 3, 4) that the ♂ continued to stay upon the host after the ♀ had dropped off gorged. The ♂ often remains attached upwards of 105 days and one specimen stayed on 355 days without a mate. Lounsbury (1) saw many ♂'s still fixed to the hide of an ox four days after its removal and when it had become putrid.

Behaviour of the sexes upon the host. Lounsbury (1) gives an interesting account of how he first observed the pairing of the sexes. In the first experiment one-third of the ♂s and only 1 ♀ attached themselves to the host out of four successive lots placed upon a cow. In a second experiment one-half of the ♂s attached themselves, but none of the ♀s did so until several days had elapsed. He writes: "Then I renewed my attempts. Twenty ♀s were dropped into the cloth (beneath the belly of the host) and in a few moments I loosened a corner to see what was happening. Great was my surprise at the sight I beheld. Pushing and crowding each other about one lone ♂ were six excited and quarrelsome members of the opposite sex, four were about another, and two more fought over a third." The ♂ attached to the host became visibly excited upon the approach of the ♀, even when she was 5–6 inches away. "He straightens his body, which before was lying against the animal, until it stands at right angles, and further expresses his desire for company by clawing the air with all eight legs. She rushes up, is caught and held by his legs, and in a moment the pair is in close embrace, the legs of each entwining the body of the other." Attached ♂s are not attractive to ♀s until the 4–7th day, and, before the ♂ is ready, he does not react upon the approach of the ♀. It is unusual for ♀s to attach themselves to the host without a ♂ being near; only 1 out of 320 ♀s was seen to attach herself in the absence of a ♂. By marking the ♂s upon a host, L. and L. J. Roberts were the first to observe that a ♂ may mate with several ♀s.]

The time required by A. hebraeum *for metamorphosis.*

Egg to Larva.

Lot N. 1732. Eggs maintained at 30° C.

Progeny of ♀ No.	Eggs laid on	Larvae emerged after	Remarks
1	16. v. 1913	49 days	[*Note* :—Lounsbury (1) gives the period as 77–81 days in summer and 185 days in winter; he made 3 observations.]
2	17. v.	48	
3	18. v.	49	
4	30. v.	53	
5	29. v.	54	
6	29. v.	53	
7	7. vi.	56	
8	7. vi.	51	
9	10. vi.	63	
10	16. vi.	50	
11	27. vii.	50	
12	28. vii.	—	
13	28. vii.	47	
14	27. vii.	51	
15	27. vii.	52	
16	28. vii.	51	
17	28. vii.	50	
18	28. vii.	46	
19	28. vii.	52	
20	29. vii.	50	
21	30. vii.	48	
*22	30. vii.	49	

Larva to Nymph.

Lot	Host	Date on which gorged tick dropped from host	Nymph emerged after	Ticks maintained at	Remarks
N. 1732	Ram	19. i. 1913	17 days	30° C. for 3 days then at 22° for 6 days, then 8 days at 30°	[*Note* :—Lounsbury (1) gives the period of 16 days when incubated; 49 days in winter. In his later paper (2) he gives 15 days at 30–33° C., 23–84 days when kept cool. Moulting is retarded at temperatures above 35° (35–41° C.)]
N. 1732	Ram	25. ii.	13	30° C.	
,,	Calf	28. ix.	12	30° C.	
N. x	Hedgehog	16. ii. 1906	46	ca. 15° C. for 29 days, then at 37° C.	
,,	Hedgehog	1. iii. 1906	16	37° C.	

Nymph to Adult.

Lot	Host	Date on which gorged tick dropped from host	Adult emerged after	Ticks maintained at	Remarks
N. 1732	Calf	21. XI. 1913	18 days	30° C.	[*Note* :—Lounsbury (1) gives the period of 18–28 days when incubated; 77 days in winter. In his later paper (2) he gives 20 days at 30–33° C., 28–98 days at lower temperatures. Moulting is retarded at temperatures above 35° (35–41° C.)]
,,	Ram	12. III.	19	,,	
,,	Ram	7. IV.	21	,,	
N. x	Goat	11. VI. 1906	44	37° C.	

Observations relating to oviposition of A. hebraeum.

Lot N. 1732. Females fed on a calf and subsequently maintained at 30° C.

Female No.	Date when ♀ dropped from host	Oviposition began after	Oviposition lasted	Days ♀ survived after ovipos. ceased	No. of eggs laid per ♀
1	7. v. 1913	9 days	32 days	8 days	13,537
2	7. v.	10	31	6	15,327
3	9. v.	11	33	4	15,228
4	19. v.	11	34	4	12,300
5	20. v.	9	35	4	16,102
6	20. v.	9	30	5	16,530
7	27. v.	11	31	13	—
8	27. v.	11	35	15	—
9	29. v.	12	25	2	—
10	7. VI.	9	33	3	—
11	18. VII.	9	27	7	—
12	18. VII.	10	23	6	—
13	19. VII.	9	31	5	—
14	19. VII.	8	29	5	—
15	19. VII.	8	29	7	—
16	19. VII.	9	24	13	—
17	19. VII.	9	26	4	—
18	20. VII.	8	35	4	18,500
19	20. VII.	8	35	1	—
20	20. VII.	9	29	7	—
21	21. VII.	9	29	2	—
22	21. VII.	9	27	4	—

Note :—To the foregoing we may add the following observations by Lounsbury (1). He observed the process in 3 ♀ which abandoned the host 18. v. 1898; oviposition began after 70–74 days and lasted 51–55 days; this was in winter. In summer, oviposition began after 14 days and lasted 42 days. When incubated, the ticks oviposited for 21 days. Lounsbury describes the process of oviposition (I have also observed it; it takes place as in other ticks; see Nuttall, VII. 1908). Lounsbury states that his assistant Fuller computed the number of eggs laid by a ♀ at 17,500 and believed a ♀ might lay from 10,000 to 20,000 eggs. One ♀ was seen to lay 370 eggs in 24 hours, averaging one egg every 3½ minutes during that period. Lounsbury has seen eggs being laid at the rate of one in 55–56 seconds.]

Longevity of unfed A. hebraeum.

Lot N. 1732. All stages maintained at room-temperature, averaging ca. 15° C.

Larvae.

Progeny of ♀ No.	Larvae emerged from egg on	No. of days which larvae survived unfed	Remarks
1	20. XI. 1912	240 days	[*Note* :—Lounsbury (4) states that unfed larvae survived for 7 months (ca. 210 days) in a corked tube kept in a cool place.]
2	6. VII. 1913	110	
3	21. VII.	221	
4	2. VIII.	266	
5	5. VIII.	184	
6	12. VIII.	335	
7	12. IX.	225	
8	13. IX.	350	
9	16. IX.	343	
10	16. IX.	310	
11	16. IX.	310	
12	17. IX.	346	
13	17. IX.	346	
14	17. IX.	340	
15	17. IX.	346	
16	18. IX.	298	

Nymphs.

Progeny of ♀ No.	Date of emergence	No. of days nymphs lived unfed	Remarks
1	10. X. 1913	250 days	[*Note* :—Lounsbury (4) states that unfed nymphs lived 6 months when kept cool.]

Adults.

Progeny of ♀ No.	Date of emergence	Examined on day
1	7–12. IV. 1913	543 there were 8 alive (8 ♂) and 307 dead (181 ♂ 126 ♀).
		660 there were 3 ♂ still surviving.
2	1. XII.	347 there were 77 alive (42 ♂ 35 ♀) and 25 dead (12 ♂ 13 ♀)
		421 there were still surviving 17 adults (15 ♂ 2 ♀) 55 out of the 77, 55 (23 ♂ 32 ♀) having died.
3	9. XII.	340 there were 515 alive (34 ♂, 181 ♀) and 310 dead (170 ♂, 140 ♀)
		432 there were still surviving 262 adults (167 ♂, 95 ♀) out of the 515, 253 (167 ♂, 86 ♀) having died.

[*Note* :—Lounsbury (2, 3) found that few adults lived longer than 6½ months when kept in a cool place; one ♀ lived 11 months unfed.]

Summary.

Amblyomma hebraeum requires three hosts upon which to feed in its larval, nymphal and adult stages. We have had no difficulty in rearing the tick under experimental conditions. The larvae attach themselves readily to sheep and hedgehogs; nymphs were fed on sheep, goats and calves; adults were fed on calves and sheep. The *larvae* remained 12–17 days (mostly 13–14 days) upon a hedgehog maintained at ca. 18° C. in September; in January, they remained 27–42 days (mostly 35 days) upon a hedgehog at 12° C.; when placed on rams, maintained in a stall at 3–4° C., in January–February, they remained upon the host 5–19 days, mostly dropping off gorged on the 8th day. Over twice as many gorged larvae abandoned a ram by day (1700 larvae) than they did by night (711 larvae); counts made during four successive nights and days all showed that more ticks dropped from the host during the daytime; as the ticks fell into a sack containing the ram's scrotum, and as they were not exposed to light, the larger number abandoning the ram by day appears clearly attributable to the ticks being shaken off by the ram whilst moving about more actively during the day. The *nymphs* remained on rams for 5–18 days, mostly 6–7 days; they remained 6–22 days on goats; they remained 4–12 days on a calf, mostly 5–6 days; the temperature at which the host is maintained slightly influences the nymphal feeding period, since the nymphs remain somewhat longer upon the host in cold weather than they do when it is warm. The *females* remain 6–12 days upon the ears of calves which had been previously infested with ♂s; of 50 ♂s which were timed, 21 remained upon the calf for 8 days, 10 for 7 days, 8 for 9 days, 5 for 10 days, 3, 2, and 1 dropping off on the 6th, 11th and 12th days respectively. The time the ♀ remains attached is influenced as in the other stages, by the blood supply obtained at the point where it attaches itself to the host; the character of the host appears also to exert an influence upon the duration of parasitism. [Lounsbury found that ♀s remained on the belly and udder of cows usually for 8 days, and on sheep and goats for 9–10 days; they may remain attached as long as 25 days to the legs and feet of goats.] *Males* remained 41–267 days [Lounsbury records 105–355 days] upon the host, *i.e.* they persist upon the host long after the latter has been abandoned by the ♀s. The ♂s may remain *in situ* and die upon the detached hide of a host. Copulation takes place upon the host; a ♂ may copulate with several ♀s, and, as Lounsbury first showed, it is only ♂s which have been attached for

some days that are attractive to ♀s. A certain amount of atmospheric humidity is required during *metamorphosis*: the time required for development from egg to larva is 47–63 days at 30° C. [Lounsbury gives 77–81 days in summer, 185 days in winter]; metamorphosis from larva to nymph takes place in 12–13 days at 30° C., in 16 days at 37° C. [Lounsbury states that 23–84 days are required if the ticks are kept cool]; metamorphosis from nymph to adult takes place on 18–21 days at 30° C., in 44 days at 37° C. [Lounsbury gives 28–98 days at low temperatures; development is retarded at 35–41° C.]. There was not much loss of life during this stage, thus 102 adults emerged from 106 nymphs in one case and 825 issued from 1145 nymphs in another. My figures seem to show a distinct *preponderance of ♂s*; thus among 1242 adults, descended from a single ♀, there were 747 ♂ and 495 ♀. The gorged and fecundated ♀s begin *ovipositing* 8–11 days after abandoning the host if they are maintained at 30° C. [Lounsbury found that oviposition commenced in winter after 70–74 days]; the ♀s may survive for 1–15 days after the process is completed, oviposition having lasted 24–35 days [51–55 days in winter according to Lounsbury]. The ♀ lays 12,300–18,500 eggs. The *longevity* of the unfed tick is marked, in our experiments several lots of larvae lived for upwards of 346 days, nymphs lived for 250 days and some adults (♂) survived for upwards of 660 days at room-temperature. Adults after fasting 412 days and upwards have fed normally upon a ram, the sexes have paired as usual and the ♀s have oviposited. Our strain of *A. hebraeum* (N. 1732) was raised in the laboratory through two generations; the *life-cycle* of the first generation was completed in 240 days, that of the second generation in 171 days. [Lounsbury (1, 4) states that at least 9 months (ca. 270 days) are required to complete the life-cycle; ordinarily it takes a year and exceptionally it may take two years.] Naturally the length of the life-cycle is greatly dependent upon temperature, warmth accelerating metamorphosis and cold greatly retarding it as is shown by the observations here recorded.

AMBLYOMMA VARIEGATUM.

The ticks to which the following record relates were (N. 1650) collected as gorged nymphs from cattle in the Lower Congo, 23–30. IV. 1912, and they arrived in Cambridge in June, most of the adults having already emerged from the nymphal skins during the journey.

Time the adult A. variegatum *remains upon the host.*

Host	Date and No. of ticks put on host	Host maintained at average temp. of ca.	No. of gorged ♀s collected on successive days	Behaviour of ♂
Ram	4. VII. 1912, 2 ♂, 3 ♀	20° C.	1 on day 51	1 ♂ dead on ram's scrotum, but still attached, on 4. III. 13, *i.e.* after 243 days!
Calf	18. VII. 3 ♂ 3 ♀	20° C.	1 on day 17 1 „ 20	
Calf	15. VIII. 6 ♂ 6 ♀	20° C.	1 on day 11 2 „ 12 1 „ 13 1 „ 15	
Calf	25. X. 3 ♂, 2 ♀	—	—	1 ♂ dead in ear-bag 24. II. 13 = after 122 days. 1 ♂ dead attached to ear 4. IV. 13 = after 161 days. 1 ♂ dead in ear-bag 22. V. 13 = after 209 days.
Calf	8. XII. 1 ♂, 1 ♀	18° C.	1 on day 11	
Calf	8. XII. 1 ♂, 1 ♀	18° C.	1 on day 11	
Calf	6. I. 1913 1 ♂, 1 ♀	15° C.	1 on day 33	
Calf	15. II. 1 ♂, 2 ♀	15° C.	1 on day 23	
			12 ♀	

Observations relating to oviposition of A. variegatum.

Date when ♀ dropped from host	Oviposition began after	Oviposition lasted	Days ♀ survived after ovipos. ceased	Temp. ca.	Remarks
4. VIII. 1912	24 days	—	—	16° C.	Eggs failed to hatch.
7. VIII.	21	—	—	—	„ „
26. VIII.	23	71 days	4 days	15° C.	„ „
27. VIII.	25	62	9	—	„ „
27. VIII.	28	62	4	—	„ „
28. VIII.	26	90	10	—	„ „
30. VIII.	24	90	—	—	„ „
19. XII.	39	38	3	12° C.	„ „
20. XII.	46	34	9	—	„ „
8. II. 1913	19	30	2	30° C.	Larvae emerged after 16 days.
10. III.	9	26	—	—	„ „ „ 31 days

Summary.

In the case of *Amblyomma variegatum* we can only record a partial life-history as our attempts to raise the species were not wholly successful; we, moreover, lost the strain.

The ♀ remained 11–20 days upon calves maintained at ca. 18–20° C.,

23–33 days upon calves are maintained at ca. 15° C.; a ♀ remained 51 days upon the scrotum of a ram maintained at ca. 20° C. The ♂ remains upon the host long after the ♀ has dropped off gorged; 4 ♂ were observed to remain attached to the host for 4–8 months; they may die whilst remaining attached. Oviposition began 9–46 days after the gorged ♀ had abandoned the host; the process lasted 26–90 days and the ♀ survived 2–10 days after it was completed. About the same number of eggs are laid as in the case of *A. hebraeum*. Out of 10 batches of eggs, laid by as many females, 8 failed to hatch (at ca. 15° C.) and 2 hatched (at 30° C.), the larvae emerging 16–31 days after the first eggs in the batch were laid. Development is therefore markedly influenced by temperature. Attempts to raise the larvae failed. The life-history appears to be essentially similar to that of *A. hebraeum*.

AMBLYOMMA SPLENDIDUM.

Of this species only a single male has hitherto reached me in a living condition. The tick emerged in June and survived unfed for about 160 days in a glass jar containing slightly dampened earth, the jar being placed at 14–19° C. in the dark. This is the same specimen which was described and illustrated in *Parasitology*, VI. p. 49, pl. VII.

DERMACENTOR RETICULATUS.

This species was successfully raised in Cambridge from two unfed adults (N. 2156, 1 ♂, 1 ♀) collected on vegetation, in Pina, Spain, 12. v. 1913, by Rev. Longin Navas, S.J., of the Colegio de Salvador, Saragossa, to whom my best thanks are due for sending them.

[Marzinowski and Bielitzer (1909, pp. 19, 24) found *D. reticulatus* (determined by L. G. Neumann) upon all the horses suffering from piroplasmosis which they examined in Russia. The tick usually occurred in large numbers on the infected horses, and it was demonstrated that adult ticks, the progeny of females collected from infected horses and fed on rabbits in the larval and nymphal stages, were capable of infecting horses with *Piroplasma caballi* Nuttall.

The Russian authors give a few data regarding the biology of the tick as follows: gorged ♀s, collected on 5–13 May from an infected horse, when maintained at room-temperature, began to oviposit after 2–3 days, laying "some hundreds" of eggs. Larvae emerged from the eggs 2–3 weeks after they were laid. An attempt to raise

the larvae on a horse failed. When placed on a rabbit, the larvae gorged in 2–3 days, having attached themselves to the host's eyelids and ears. A few dozen larvae placed on the rabbit brought about its death, although nothing more than an anaemic condition of the animal was observable at autopsy; 30 nymphs produced a similar effect when they were fed upon a second rabbit[1]. From 5 gorged nymphs, taken from the second rabbit, there emerged 5 adults (3 ♂, 2 ♀) after 17–18 days; three of these adults (1 ♂, 2 ♀) produced piroplasmosis in a horse upon which they were placed 15–16 days after their emergence from the nymphal skin. The horse showed *P. caballi* in its blood and a temperature of 40° C. on the 12th day after the tick infestation took place. Some unfed larvae survived for 6 months.]

The time D. reticulatus *remains upon the host.*

Host	Date when ticks were put on host	Host maintained at average temp. of	No. of gorged ticks collected on successive days	Remarks
Larvae.				
Ram	8. VII. 1913	19° C.	164 on day 3	Larvae placed on host 24 days after emergence.
			450 „ 4	
			111 „ 5	
			29 „ 6	
			754	
Nymphs.				
Ram	30. VII. 1913	19° C.	55 „ 6	Nymphs placed on host 14 days after emergence.
			90 „ 7	
			84 „ 8	
			13 „ 9	
			5 „ 10	
			247	
Adults (♀).				
Ram	20. V. 1913	19° C.	1 on day 9	
Ram	30. IX.	14° C.	1 „ 13	
Ram	14. X.	9° C.	2 „ 8	
			1 „ 12	
			1 „ 13	
			2 „ 15	
			8 ♀	

[1] Hadwen and Nuttall (1913) *Parasitology*, VI. 299–301, observed deaths in guinea-pigs to which larvae and nymphs of *Dermacentor venustus* were applied. Aragão (1912, pp. 96 *et seq.*) also noted fatal effects following the infestation of toads and snakes with *Amblyomma agamum*. In the absence of any parasites in the blood in any of these cases the deaths may, provisionally, be attributed to toxic secretions emanating from the ticks.

Time required by D. reticulatus *for metamorphosis at* 30° C.

Egg to Larvae.

Eggs laid on	Larvae emerged after
1. VI. 1913	12 days
21. XI.	17
16. XII.	19

Larvae to Nymph.

Host	Date on which gorged larvae dropped off host	Nymphs emerged after
Ram	11. VII. 1913	5 days

Nymph to Adult.

Host	Date on which gorged nymphs dropped off host	Adults emerged after
Ram	5. VIII. 1913	12 days

Observations relating to oviposition of D. reticulatus.

The females were placed together with males upon a ram.

Tick No.	Date when gorged ♀ dropped from ram	Oviposition began after	Oviposition lasted	Days ♀ survived after oviposition ceased	No. of eggs laid per ♀	♀ maintained at aver ge temp. of
1	29. v. 1913	3 days	6 days	21 days	—	30° C.
2	13. x.	50	15	13	x	15° C.
3	22. x.	24	20	0	—	—
4	22. x.	26	18	0	x	—
5	26. x.	38	12	0	x	—
6	27. x.	24	23	0	3994	—
7	29. x.	44	—	—	x	—
8	29. x.	60	23	10	x	—

The sign x in the 6th column denoted that the eggs failed to hatch.

Longevity of unfed D. reticulatus.

Larvae [Marzinowski and Bielitzer saw unfed larvae survive for 6 months].
Nymphs emerged on 16. VII. 1913 and survived only 37 days at 18° C.
Adults emerged on 17. VIII. 1913 (81 ♂, 110 ♀);

1 ♂ survived for 474 days at room temperature.
1 ♀ „ 450 „ „ „ „

Behaviour of the sexes upon the host.

Observation 1. On 20. v. 1913, 1 ♂ and 1 ♀ were placed upon a ram's scrotum. They attached themselves quickly at some distance from each other. After 24 hours the ♀ had not changed her position, the ♂, partly fed, was wandering about. The ♂ was removed, and, on 27. v., again placed with the ♀ when copulation occurred at once.

Observation 2. On 30. IX. 1913, 3 ♂ and 3 ♀ were placed upon a ram's scrotum. On 1. X., they were all wandering about. On 2. X., 1 ♀ had attached herself. On 3. X., 2 ♂ were attached. On 8. X., 1 ♀ was found partly gorged and 1 ♂ was wandering about. On 9. X., the ♂ and ♀ were found in copulation.

Observation 3. On 14. X., 1913, 6 ♂ and 6 ♀ were placed upon a ram's scrotum. On 15. X., a pair were found in copulation, the rest were attached in different places. On 17. X., all the pairs were in copulation.

Summary.

Dermacentor reticulatus requires 3 hosts upon which to feed in the larval, nymphal and adult stages. All stages are readily reared on sheep. [Marzinowski and Bielitzer reared immature stages on rabbits and adults on a horse.] Larvae and nymphs attached themselves quickly to the host 14–24 days after emergence; adults fed promptly after an interval of 44–58 days; doubtless they would have fed sooner if they had been tried. The tick feeds upon the ram for 3–6 days (mostly 4 days) as a *larva*, for 6–10 days (mostly 8 days) as a *nymph*, for 9–15 days as an *adult* (♀). When adults of both sexes are placed upon the host they usually scatter and after the ♂ has fed for a time he seeks the ♀, copulation taking place upon the host. There is evidence that the ♂ tends to wander about, and this behaviour coupled with the observation, cited below, that ♀s are somewhat more numerous than ♂s, renders it probable that the latter may copulate with several ♀s. The time required for *metamorphosis* was determined (at 30° C. only) as follows: it took 12–19 days before the larvae emerged from the egg, 5 days for metamorphosis from larva to nymph and 12 days [17–18 days in spring according to Marzinowski and Bielitzer] for metamorphosis from nymph to adult. *Oviposition* commenced, according to temperature, 3–24 days after the gorged and fecundated female has abandoned the host, the process lasting 6–23 days, and during this period the female lays about 4000 eggs. Parthenogenesis has not been observed to occur. The loss of life observed in raising this tick under experimental conditions is less than is frequently observed in other species; thus, from a batch of 754 gorged larvae (many larvae and nymphs being preserved for our collection) we raised 247 nymphs which after engorgement, gave rise to 191 adults. These 191 adults were all descended from a single female (No. 1 in our protocol p. 423) and comprised 81 ♂ and 110 ♀. The *longevity* of unfed larvae was not determined by us [they may survive unfed for 6 months according to Marzinowski and Bielitzer]; unfed nymphs survived for 37 days; we have seen a ♂ survive for 474 days and a ♀ for upwards of 450 days; the ticks at all stages

being maintained at room temperature in semi-darkness in bottles. From the data given in the protocols, the shortest time required for the completion of the *life-cycle* would be 80 days, but this period is doubtless considerably prolonged under natural conditions.

The part played by *D. reticulatus* in pathology is referred to on p. 422.

DERMACENTOR VENUSTUS.

The ticks to which the following record relates were (N. 1731) received from Dr C. Gordon Hewitt, Dominion Entomologist, Central Experiment Farm, Ottawa, Canada, 22. VII. 1912. The parent females were collected from horses imported into British Columbia from Yakima, State of Washington, U.S.A., in v. 1912. The females began to oviposit 9. VI. 1912, and larvae had emerged from the eggs when they arrived in Cambridge.

[The first to raise this tick experimentally was Ricketts* in connection with his investigations upon Rocky Mountain Spotted Fever, wherein he showed that it transmits the disease. The biology of the species has also been studied by Hunter and Bishopp (17. XI. 1911, pp. 20–29) in Texas in conjunction with W. V. King in Montana. I am much indebted to Dr M. B. Maver, who collaborated with the late Dr Ricketts in Chicago, for a personal communication received in May, 1912, dealing briefly with the life-history of a strain she had received from Montana and of which she sent me specimens now in my collection. Ricketts' reports relate to experiments with different species of *Dermacentor* and deal chiefly with medical matters; his data relating to the biology of the tick are somewhat obscure owing to his including several species in his experiments. Some data, contained in the paper by Hadwen (*Parasitology*, VI. 283–297), are included in the summary at the end of this section; this author's observations were made in British Columbia.

The following account of the life-history of *D. venustus* is based on the observations of Hunter and Bishopp[1] and of Maver[2], whose authority for the various statements is indicated in the next paragraph by reference numbers. The periods required for feeding, metamorphosis, etc., given by Dr Maver, are average periods based on many observations.

* Ricketts' papers are cited in *Ticks*, Bibliographies I and II, *q.v.*

The time the tick remains upon the host : larvae feed for 2–8 days (7 experiments)[2] or 3–7 days[2]; nymphs feed for 4–9 days (7 experiments)[1] or 3–7 days[2]; females feed for 8–14 days either on the ox or guinea-pig (5 experiments)[1] or 5–15 days[2]. *Metamorphosis* from egg to larva lasts 15–41 days in Texas, 34–51 days in Montana[1] or 14–25 days[2]; from larva to nymph it lasts 6–21 days (8 experiments)[1] or 13–20 days[2]; from nymph to adult it lasts a minimum of 12 days to a maximum of 170 days (8 experiments)[1] or 20–40 days[2]. *Oviposition*, reckoned from the time the replete female abandons the host, begins after 6–13 days in warm weather and after 41 days when it is cool[1] or it commences after 8–14 days[2]; the process lasts 30 days[1] or 8–20 days[2], the female dying a few days later[1]; the number of eggs laid is usually about 4000[1] or 2500–3000[2]. Copulation occurs on the host[1, 2], the ♂ seeking the ♀ some 4–8 days after the sexes have attached themselves; the ♂ remains upon the host after the ♀ has dropped off, and the ♂ may copulate with several ♀s[1]. *Longevity* of unfed ticks: larvae usually die in 30 days, but a few survive up to 117 days; nymphs live for over 300 days; adults captured on vegetation in the spring, survived unfed for 413 days[1]. *Season :* adults which emerged in July to October became active and fed in January and March, this corresponding with their behaviour in nature where they remain torpid for 4–5 months after emergence[2]. The unfed nymphs and adults hibernate, find hosts in March to July (when they attack man) in Montana; the females which feed in spring lay eggs which lead to adults in September. Nymphs are found on small wild animals in March to July inclusive, they hibernate as unfed adults. The adults are found on large wild and domesticated animals and on man, but the immature stages rarely if ever occur on other than small animals. A very full list of the natural hosts of *D. venustus* is given by Hunter and Bishopp (*q.v.* pp. 28–29). The *life-cycle* is usually completed in 2 years, but it may require 3 years for its completion[1].

According to the investigations of Ricketts on Rocky Mountain Spotted Fever, *D. venustus* transmits the virus of the disease as a nymph if it has fed upon an infected host (man, monkey, guinea-pig, etc.) in the larval stage; when infected as a nymph, the tick is infective as an adult, and larvae, the progeny of an infected female tick, are also infective.]

[1] Hunter and Bishopp. [2] Maver.

The time D. venustus *remains upon the host.*

Larvae.

Host	Date when put on host	Host kept at	No. of gorged ticks collected on successive days	Remarks
Guinea-pig	26. VII. 1912	21° C.	21 on day 3 27 „ 4 29 „ 5 14 „ 6 91	
Guinea-pig	6. VIII. 1912	21° C.	121 on day 3 26 „ 4 37 „ 5 1 „ 6 185	
Guinea-pig	7. IV. 1913	—	3 on day 2 473 „ 3 476	Progeny of ♀ No. 1.
Ram	23. IX. 1913	—	23 on day 6	Progeny of ♀ No. 2.
Nymphs.				
Guinea-pig	13. IX. 1912	19° C.	1 on day 5 6 „ 6 4 „ 7 7 „ 8 1 „ 9 2 „ 10 21	Nymphs had fasted 36 days before being put on host.
Ram	2. VI. 1913	—	6 on day 6 10 „ 7 2 „ 8 4 „ 9 2 „ 10 3 „ 11 27	Nymphs had fasted 46 days.
Adults (♀).				
Ram	24. XI. 1912	6° C.	1 on day 15	3 ♂ and 4 ♀ were put on ram.
„	10. VII. 1913	—	1 „ 8	3 ♂ and 3 ♀ were put on ram.
Lamb	14. IV.	—	1 „ 5	Recorded by S. Hadwen.
„	14. IV.	—	1 „ 8	„ „ „

The time required by D. venustus *for metamorphosis.*

Egg to Larva.

Eggs laid on	Larvae emerged after	Eggs maintained at	
20. XII. 1912	38 days	22° C.	
21. VII. 1913	16	30° C.	
23. IV.	7	ca. 32° C.	Record by S. Hadwen, the unfed ♀s were taken from sheep at Chopaka, Brit. Columbia, and transferred to a lamb.
26. IV.	10	ca. 32° C.	

Larva to Nymph.

Host	Date when gorged tick dropped off host	Nymphs emerged after	Ticks maintained throughout at
Guinea-pig	29. VII. 1912	10 days	24° C.
,,	9. VIII.	11	,,
,,	10. IV. 1913	7	30° C.
,,	29. IX.	6	,,

Nymph to Adults.

		Adult emerged after	
Guinea-pig	18. IX. 1912	14 days	24° C.
Ram	8. VI. 1913	15	ca. 30° C.

Observations relating to oviposition in D. venustus.

Obs. No.	Host	Date when gorged ♀ dropped from host	Oviposition began after	Oviposition lasted	Days ♀ survived after ovipos. ceased	No. of eggs laid per ♀	Temperature at which ♀ was maintained
1	Ram	9. XII. 1912	11 days	33 days	14 days	—	24° C.
2	,,	18. VII. 1913	3	18	14	7140	30° C.
3	Lamb	19. IV.	4	—	—	—	ca. 32° C.
4	,,	22. IV.	4	—	—	—	,,
5	Jackal	2. VIII.	5	10	1	—	30° C.
6	Dog	25. VII.	4	22	11	3574	,,

Note:—Observations 3 and 4 were made by S.Hadwen in British Columbia. In observation 5 the ♀ abandoned the jackal in a semi-gorged condition, there being no ♂ upon the host; all the eggs failed to hatch. In observation 6 the ♀ was partly gorged when removed from the dog in which it produced *tick paralysis* (see Hadwen and Nuttall, *Parasitology*, VI. 298); it was also placed upon the host in the absence of a ♂ and laid eggs which were sterile.

Longevity of unfed D. venustus.

Larvae, which emerged 27. I. 1913, were active after 67 days, when they fed upon a guinea-pig; they were subsequently raised to adults. *Adults*, which emerged 2. X. 1912, survived for 356 days when they attached themselves to a host.

Summary.

Dermacentor venustus is a 3-host tick; it is readily reared under experimental conditions. All stages were fed by us on sheep; larvae and nymphs were fed on guinea-pigs. In nature, the tick occurs on a great variety of hosts as has been shown by American authors. *The time the tick remains upon the host:* as a larva is 2–6 days, mostly 3 days [2–8 days[1], [2]]; the nymph feeds for 5–11 days, mostly 6–7 days [3–9 days[1], [2], [3]]; the female feeds for 5–15 days [5–15 days[1], [2] or 4–10 days[3]; the male feeds for 3–4 days before he seeks the female and during this period may alter his position several times[3]]. *Metamorphosis* from egg to larva lasted 7–10 days at 32° C., 16 days at 30° C., 38 days at 22° C. [14–51 days [1], [2] or 36 days in summer]; from larva to nymph it lasted 6–7 days at 30° C., 10–11 days at 24° C. [6–21 days[1], [2], 24–38 days in summer[3]]; from nymph to adult it lasted 14–15 days at 24–30° C. [12–170 days, minimum and maximum[1] or 32 days in summer and 84–94 days in winter[3]]. *Oviposition*, reckoned from the day the female abandons the host, begins after 3–5 days at 30–32° C., after 11 days at 24° C. [6–41 days depending upon temperature[1]]; the process lasts 10–33 days at 24–32° C. [8–30 days[1], [2]] and the female may survive 1–14 days after laying has ceased. The fertile eggs laid by one of our females numbered 7140 [2500–4000 are stated to be the usual number[1], [2]; Hadwen observed a female which laid 474 eggs in 24 hours, *i.e.* on an average of 1 egg every 2·3 minutes[3]]; two of our unfertilized females laid no eggs, but a third laid 3574 eggs which did not hatch. *Copulation* occurs upon the host [the process has been observed by Hadwen, the union lasted 33 minutes and occurs in a similar manner to what we have observed in *Ixodes*, the male appears to seek the semi-gorged female by preference for the purpose[3]]. The male remains upon the host for an undetermined period after the female has dropped off; it is clear that a ♂ may copulate with several ♀s. *Longevity:* larvae which had fasted 67 days fed readily when placed on a guinea-pig [if unfed they usually die in 30 days, but they may survive up to 117 days; unfed nymphs may live over 300 days[1]]; adults, after fasting 356 days, readily attached themselves to a host [captured on vegetation in the spring, they survived unfed for 413 days; all stages may hibernate in nature[1]]. The *life-cycle* may be completed in 68 days under the most favourable conditions, judging from our laboratory experiments [the time required is usually 2 years and may be 3 years[1]].

[1–3] The data enclosed in brackets are cited from (1) Hunter and Bishopp, (2) Maver and (3) Hadwen.

The part played by *D. venustus* in pathology is referred to on p. 426; see also Hadwen (*Parasitology*, VI. 283–297) and Hadwen and Nuttall (*Ibid.* 298–301) in connection with tick paralysis.

HAEMAPHYSALIS CINNABARINA.

This tick (*H. chordeilis* of American authors) requires three hosts upon which to feed as a larva, nymph and adult. The first to raise the tick were Hooker, Bishopp and Wood (1912, p. 98), who state that the *larvae* feed 5–12 days on rabbits or guinea-pigs; they twice failed to feed on fowls. Metamorphosis from larva to nymph takes 14 days at ca. 26° C. or 76 days at 12° C. Some unfed *nymphs* lived up to 55–75 days. Nymphs, placed on cattle, fed for 5–8 days, and then underwent metamorphosis to adults in 26 days at 20° C. or in 186 days at ca. 15° C. (average temperature). *Adults* survived unfed for 100–305 days. A female (probably unfertilized) remained for 19 days upon an ox; she then dropped off replete and survived for 172 days, but did not oviposit.

The following observations were made by me in Cambridge with the progeny of 2 ♀ (N. 2452) taken from *cattle* in Winnipeg, Canada, and for which I am indebted to Mr J. R. N. Harrison. The ticks were raised on rabbits in experimental cages at room temperature (about 15° C.) in the laboratory; they were kept in an incubator at 30° C. during metamorphosis.

The recently emerged larvae were placed on a rabbit on 27. XI. 1913:

No. of gorged larvae collected on successive days	
7	on day 5
270	„ 6
560	„ 7
306	„ 8
160	„ 9
98	„ 10
51	„ 11
15	„ 12
12	„ 13

The first nymphs emerged on 11. XII. 1913, *i.e.* metamorphosis from larva to nymph lasted 10–11 days at 30° C. On 6. I. 1914 the nymphs (100) were placed on a rabbit.

No. of gorged nymphs collected on successive days	
3	on day 8
4	„ 9
3	„ 11
5	„ 12
1	„ 13
2	„ 14
3	„ 15
2	„ 17

The first adults emerged on 10. II. 1914, *i.e.* metamorphosis from nymph to adult lasted 28 days at 30° C.

Longevity of unfed ticks : larvae which emerged 7. XI. 1913, died in 43 days. *Nymphs* which emerged 11. XII. 1913, died after 34 days (at room temperature).

My results agree with those of the American authors, but the nymphs remained longer upon the host.

HAEMAPHYSALIS CONCINNA.

The only observations on the biology of this species are by Brumpt in France, who has kindly supplied me with his MS. notes thereon.

Brumpt has found the adults only upon deer, attached in the cervical region, especially along the mane, occasionally at the base of the ears, and rarely elsewhere. When placed experimentally upon dogs, they attached themselves anywhere. The sexes are found attached close together upon deer. Nymphs and larvae were found by Brumpt on deer and hedgehog and it is probable that they occur on other mammals; they attach themselves anywhere upon the hosts mentioned.

Time the tick remains upon the host.

The *larvae*, a few days after emergence, attach themselves quickly to a variety of hosts (deer, hedgehog, dog, guinea-pig, rat, mouse) and gorge themselves with blood or lymph in 3–10 days; nearly all of them abandon the host in 3–5 days.

The *nymphs*, a few days after emerging, attach themselves to the same hosts as do the larvae and feed to repletion in 3–12 days, mostly abandoning the host in 4–5 days.

The *adults* after fasting for weeks or months, attach themselves to the host whereon they copulate, probably after 4 days, for the sexes are then found attached close together with their venters juxtaposed.

The fertilized female becomes replete in 8–10 days; she is then slate-coloured and weighs on an average, when fully gorged, 0·35 g. Unfertilized females may stay for several weeks upon the host remaining about a third gorged.

Time required for metamorphosis.

Egg to larva: the larvae emerge some weeks after the eggs are laid and they are capable of living for a long time unfed.

Larva to nymph: nymphs emerge 17 days after they abandon the host as gorged larvae, when maintained at 25–30° C. From 64 gorged larvae found upon a hedgehog, 64 nymphs emerged.

Nymph to adult: adults emerge after 22 days at 25° C. From 4 gorged nymphs found on a stag at Chantilly there emerged 4 ♂ after two months; from 15 gorged nymphs found on a hedgehog there emerged 15 adults. Certain incompletely gorged nymphs undergo metamorphosis to adults very slowly and they often die before it is completed. *H. concinna* differs in this respect from certain species of ticks, for instance *Amblyomma cajennense* (as seen by Aragão, 1912, p. 96), *Rhipicephalus appendiculatus* and *R. sanguineus* (Nuttall, 1913, p. 195; Cunliffe, 1914, p. 372), *Dermacentor reticulatus* (as seen by Brumpt), wherein imperfectly gorged nymphs were found to give rise to small adults.

Oviposition.

At a temperature of 18° C., oviposition occurs in about the second week. The eggs are larger than those of *Ixodes ricinus*, they are dark salmon-coloured. Each female usually lays upwards of 1000 eggs.

Season.

From the accompanying table relating to Brumpt's observations on the seasonal occurrence of *H. concinna* (and *H. inermis*) in France, it will be seen that all stages were encountered on *deer* in February–April and October, none were found in January and September, 1912, and none were encountered in November–December of 1912 and 1913. All stages were most numerous in March and April, usually few or none being encountered later. Observations for the 4 months May–August are lacking. In one instance (April, 1912) the number of ♂s greatly exceeded that of the ♀s encountered on one host. On two *hedgehogs* examined at Chantilly (27. VI. 1911 and 6. VI. 1912) he found immature stages only: 15 nymphs, 64 larvae and 19 nymphs, 174 larvae respectively.

Table showing the prevalence of Haemaphysalis spp. *on Deer in France, as observed by Dr E. Brumpt.*

No. of Deer examined	Date	Locality[1]	*H. concinna*	*H. inermis*	*H. cinnabarina* var. *punctata*
	1911				
1	3. xi. 1911	Fontainebleau	—	♂, ♀ 14	—
1	7. xii.	,,	—	♂, ♀ f. numerous	—
1	16. xii.	,,	—	♂, ♀ 52	—
	1912				
1	24. i.	—	—	♂ 1	—
1	13. ii.	Indre	♂ 1, ⊙ 2, L 1	♂ 3, ♀ 3	♂ 1
1	20. ii.	Fontainebleau	♂ 5, ⊙ 3,	♂ 4, ♀ 7	—
1	27. ii.	Vienne	♂ 18, ♀ 14, ⊙ 3	♂ 2, ♀ 2	—
1	28. ii.	Indre	♂, ♀ many	♂, ♀ many	—
1	18. iii.	Compiègne	♂ 3	—	—
1	4. iii.	Fontainebleau	♂, ♀ few, ⊙ 1, L 3	♂, ♀ few	—
1	30. iii.	Indre	♂ 37, ♀ 34, ⊙ 15, L 2	♂ 2, ♀ 15	—
1	13. iv.	Fontainebleau	♂, ♀, ⊙, L f. numerous	♂, ♀ f. numerous	—
1	17. iv.	,,	♂, ♀, ⊙, L f. numerous	♂, ♀ f. numerous	—
1	24. iv.	,,	♂ 150, ♀ 30, ⊙ 40, L 10	♂ 1	—
1	31. ix.	Chantilly	—	—	—
1	3. x.	,,	⊙, L 2	—	—
1	8. x.	,,	♂, ♀ f. numerous, ⊙ 1, L2	—	—
1	14. x.	,,	—	—	—
1	21. x.	,,	⊙ 1	—	—
1	21. x.	,,	♂ 1, ⊙ 1	—	—
1	24. x.	,,	—	—	—
6	18. and 19. xi. and xii.	,,	—	—	—
	1913				
1	28. iv. 1913	Chantilly	♂, ♀, ⊙. L many	—	—
1	30. iv.	,,	♂ 30, ♀ few	—	—
29					

The signs ⊙ and L denote nymphs and larvae respectively.

Insect parasites of H. concinna.

Brumpt has several times found the nymphs of *H. concinna* at Chantilly and Fontainebleau to be infested with *Ixodiphagus caucurtei* du Buysson. Under experimental conditions, the nymphs were readily attacked by the chalcidid, but only about 2–4 % became parasitized.

[1] Fontainebleau (Dépt. Seine-et-Marne); Dépt. Indre; Dépt. Vienne; Compiègne (Dépt. Oise); Chantilly (Dépt. Oise).

HAEMAPHYSALIS INERMIS.

The biology of this species has been studied by Dr E. Brumpt of Paris, who has kindly placed his notes at my disposal, thus enabling me to compile the following account of the life-history of *H. inermis*.

Brumpt finds that the adults, which are very active, occur commonly on deer in France during the months November to April inclusive. They quickly abandon the host and readily reattach themselves to the hedgehog or dog in the laboratory. The ticks occur in all situations upon the host, but they attach themselves by preference, as does *I. ricinus*, in places where the skin is thin. On deer, they occur in the axillary and inguinal regions and occasionally upon the ears.

H. inermis requires three hosts upon which to feed in the larval, nymphal and adult stages respectively. Both sexes occur upon the host on whom copulation takes place. Brumpt has never found the sexes attached at the same spot on the host as is usually seen in *H. concinna*.

Time the tick remains upon the host (*Laboratory Experiments*).

The *larvae*, when a week old, attach themselves immediately in any situation upon the host, be it either a mammal (hedgehog, mouse, rat) or reptile (lizard); they *gorge very rapidly*, some being replete in 1½ hours; the majority, however, engorge in 2–3 hours, whilst some feed for 20 hours. Their bodies appear bright red at first, owing to the blood ingested, but after some days they assume a bluish hue.

The *nymphs* are often ready to feed a few days after emergence; they *gorge rapidly*; some are replete within 1 hour, the majority gorge within 2 hours, whilst others remain longer upon the host, but in no case do they remain attached longer than 24 hours upon a mammal. They suck blood for longer periods when attached to cold-blooded animals (lizards) at room temperature.

The *females* may remain attached to the host for weeks whilst awaiting the male, during which time they appear but partially fed. In the presence of the male, *i.e.* when the female is fecundated, she usually grows replete and abandons the host in about 8 days.

Time required for metamorphosis.

Egg to larva: the larvae emerge 7–8 weeks after the eggs are laid when the latter are kept at 18° C.

Larva to nymph: the nymphs emerge after 17 days at 25° C., the time being reckoned from when they dropped from the host as gorged larvae.

Nymph to adult: an exceptionally long time is required for metamorphosis at this stage. When the nymphs have fully gorged themselves they moult after 6 months at 15–25° C., some may, however, require 10 months, and incompletely fed specimens are found to be still active after 16 months.

Observations relating to oviposition.

Oviposition usually begins on the 5–6th week (at 18° C.) after the replete and fecundated female has abandoned the host. The eggs are large, dark salmon coloured, and only number about 200 per female.

Season.

From the table on p. 433 which contains Brumpt's observations on *H. inermis* and *H. concinna*, we learn that the adults of *H. inermis* occur on deer in France during the six months November to April inclusive. Observations for the four months May–August are lacking. The ticks were not found in September–October.

Remarks upon the exceptional behaviour of H. inermis.

H. inermis offers an exception to all the ticks whose life-histories we know in that it gorges with remarkable rapidity both in the larval and nymphal stages. It is the rule in Ixodid ticks for all stages to remain attached to the host for several days. In Argasidae we do not know of a species where the larvae feed as rapidly as does the larva of *H. inermis* although the nymphs are rapid feeders. Whilst this habit of rapid feeding may favour the survival of the species, the long time required for the process of oviposition and for metamorphosis from egg to larva and from nymph to adult must exert a contrary effect. The phenomenon observed in *H. inermis* by Brumpt is very interesting and worthy of attention.

Insect parasites of H. inermis.

A chalcidid called *Ixodiphagus caucurtei* du Buysson, 1912 (p. 246) was discovered by Brumpt in the nymphs of *Ixodes ricinus* in France and raised by him to the seventh generation in the laboratory. This insect attacks the nymphs of *H. inermis*. Whereas scarcely 1 % of these nymphs become infested, all of the nymphs of *I. ricinus*, *Dermacentor venustus*, *D. reticulatus* and *Rhipicephalus sanguineus* in which the parent *I. caucurtei* deposits her offspring, die and yield imagines of *Ixodiphagus*.

HYALOMMA AEGYPTIUM.

The following notes supplement those already published (*Parasitology*, VI. pp. 105–110):

Time the adult tick remains upon host, especially the males.

On 18. XI. 1913, 12 ♂ and 12 ♀ were placed upon calf XXII; they belonged to the same lot previously reported upon (N. 1305 *a*). The ♀s dropped off gorged as follows: 4 on day 8, 2 on day 9 and 2 on day 10; 4 ♀s were lost. Of 12 ♂s there remained 9 alive and attached to the host until it was killed on 16. I. 1914, *i.e.* 60 days after they were placed on the calf; 3 of the 12 ♂s were lost.

Longevity of unfed adults.

Adults which emerged on 3. XII. 1912 were maintained at room temperature in the laboratory in a jar covered with gauze. On 13. XI. 1914 they were turned out and examined. The ticks had been originally placed in the jar as gorged nymphs of which there were 340. Only 4 of the nymphs failed to undergo metamorphosis. On the date mentioned above, *i.e.* 710 days after emergence, there were found 103 (22 ♂, 81 ♀) living and 233 (61 ♂, 172 ♀) dead adults in the jar. After 759 days there were still 20 ♂ and 47 ♀ living. A couple of ♀s after fasting 817 days have been fed on a ram, have mated with ♂s that have fasted over 210 days, and are at the time of writing engaged in ovipositing *H. aegyptium* would appear for the present to hold the record in the matter of longevity when unfed.

Proportion of the sexes.

The adults referred to in the previous paragraph were all part of the progeny of a single ♀ (No. 13) which laid 13,940 eggs; these adults numbered 336 and may be regarded as a fair sample. The sexes were represented by roundly three times as many females as males: 83 ♂ and 253 ♀.

HYALOMMA SYRIACUM.

A gorged ♀ was brought to the laboratory by Dr E. Hindle some days after she had dropped from a tortoise. Oviposition began on 13. VII. 1913 and lasted 19 days, the ♀ dying a day later. The number of eggs laid was 6118, and the first larvae appeared 11 days after the first eggs were laid. The ♀ and eggs were maintained at 30° C. (Incidentally I would mention that the lady to whom the tortoise belonged mothered the tick for some days in the fond belief that it was a young tortoise!)

IXODES PUTUS.

(Additional notes to Part I (*Parasitology*, VII. pp. 83–84.)

In the record relating to the longevity of unfed larvae, nymphs and adults of this species, published in Part I, some specimens, N. 1703, were still alive when the proof of the paper was passed for press. The following protocols complete those previously published since they give the day on which the last survivors of each lot were found dead.

Longevity of unfed I. putus.

The time in each case is reckoned from the date of last ecdysis. The ticks were maintained in semi-darkness in a cupboard and at room temperature ranging from about 12° C. in winter to 18° C. in summer.

Larvae.

Progeny of ♀ No.	Date of emergence	Day on which the last survivors died
1	18. XI. 1912	197 days
3	7. XI.	205
4	21. X	191
5	5. XI.	150
7	18. XI	196
9	21. X.	225
11	30. X.	184
12	23. X.	237
15	5. XI.	209
16	21. X.	224
18	9. X.	236
19	30. X.	215
20	30. X.	214
25	5. XI.	209
26	18. X.	226
28	7. XI.	208

Nymphs.

Lot No.		
35	4. VII. 1912	364 days

Females.

32	ca. 17. VII. 1912	351 days
33	„ „	378

Summary.

The longest period which unfed larvae survived was 237 days, whilst nymphs survived up to 364 days, males up to 376 days (see Part I, p. 84) and females up to 378 days.

Effect of the bite of I. putus.

In Part I (pp. 84–85) the effects of the bite of a female were described. I was bitten on 13. VII. 1912, and recorded the after-effects up to 20. III. 1913. The area about the seat of the bite remained discoloured until the spring of 1914, and it itched at intervals of about two weeks or more. The itching sensation has continued to occur suddenly at intervals of a month or so but it now subsides rapidly. All signs of the bite have disappeared. The last dates on which the itching returned was on 9. XII. 1914, 3–5 and 20. I. 1915.

RHIPICEPHALUS APPENDICULATUS.

To the account of the biology of this species given in Part I (*Parasitology*, VI. pp. 111–118), the following note should be added regarding the *proportion of the sexes* observed among the progeny of an undetermined number of females of the strain received from South Africa in 1910.

The ticks were fed as nymphs upon calves.

Lot No.	No. of gorged nymphs collected	Date when the adults emerged	No. of adults of both sexes	Proportions of each sex ♂	♀
1	74	26. I. 1913	71	34	37
2	270	4. II.	82	39	43
3	154	24. III.	151	78	73
4	218	24. V.	203	105	98
5	47	29. VII.	42	16	26
			549	272	277

The numbers of each sex may therefore be regarded as equal. The loss of life during metamorphosis from nymph to adult is very slight in four out of the five observations; only in Lot 2 was there a considerable mortality amongst the nymphs.

RHIPICEPHALUS BURSA.

The ticks used for the study of the biology of this species were derived from Hammam Meskoutine, Algeria, whence I received (N. 1305 *b*) two gorged females that had been collected from sheep by M. Paul Dechabert at my request. The females laid numerous eggs whence larvae emerged on 5. IX. 1911, that is 50–51 days after the first eggs were laid. We have maintained the strain to date; all our stock is descended from one of the females before mentioned.

[The only author who has studied the biology of *R. bursa* is Motas (1904, pp. 33–39) who demonstrated that the tick is the vector of piroplasmosis in sheep. He states that the disease occurs in May to November in Roumania, the sheep being then found heavily tick-infested. The ticks are chiefly found attached to bare parts of the sheep's skin, notably about the axillae, prepuce, vulva and anus, the anterior part of the abdomen and inside the ears. I shall quote this author's data *in extenso*; merely rearranging them in conformity with the scheme adopted in this paper.

R. bursa is a two-host tick, feeding upon one host as a larva and nymph and upon the second host as an adult. The *larvae*, under experimental conditions, attach themselves to sheep upon the face and about the base of the ears, becoming fully gorged in about 8 days; they then appear red, owing to the ingested blood; they remain attached to the host although they have ceased to feed, and, after a period of 2–4 days, they assume a dirty white colour. After a further period of 1–2 days, they moult (whilst upon the host) and emerge as *nymphs* which reattach themselves at the same spot where they fed as larvae. The nymphs gorge in 10 days, attaining a length of 3–3·5 mm., and 1–2 days later they abandon the host to undergo metamorphosis to adults upon the ground. The duration of parasitism depends to some extent on the place of attachment upon the host. The *adult* (♀), if fertilized, feeds upon the host for 7–8 days; if unfertilized, he states, that the females do not feed (which is wrong, *vide infra*); the ♂ does not seem to wander about upon the host (this is incorrect).

If an isolated male is detached and placed near an attached but unfertilized female, copulation occurs quickly and the female now proceeds to feed rapidly. Motas states that there is a marked difference in the *proportion of the sexes*, there being barely 1 ♂ to 3 ♀ (my results *q.v.* give no such great disproportion). That the sexes are ready to feed when placed together upon the host is clear from his statement that a day after he had placed 50 adults on a ram 16 (5 ♂, 11 ♀) were found attached. *Metamorphosis* lasts from egg to larva 20–30 days, from larva to nymph (upon the host) 11–14 days, from nymph to adult 45–55 days (in cool weather). *Longevity:* larvae survived unfed for 2–2½ months and then attached themselves readily to sheep.

Motas first succeeded in infecting a sheep with piroplasmosis by removing 50–60 adult ticks (which did not appear as yet to

have fed) from the sheep of an infected herd. These ticks were placed upon an experimental animal which showed parasites in its blood and fever (40° C.) on the 10th day. It was found, as in the case of *Haemaphysalis leachi* and *Piroplasma canis*, that ticks descended from an infected mother were innocuous as larvae and nymphs but infective as adults.

The ticks are stated by Motas to have been identified by Neumann, but Dönitz (1905, pp. 107–109), has thrown doubt upon the correctness of the determination because in the collections of the Berlin Museum, ticks determined by Neumann as *R. bursa*, were found by him (Dönitz) to be *R. appendiculatus* Nn., 1901. The error, as Dönitz states, is probably explained by the circumstance that Neumann, at the time he identified the Berlin specimens, had not found the last-named species and consequently confused the two. Dönitz (1907, p. 103), moreover, doubts the accuracy of Motas' observation that *R. bursa* is a two-host tick.

There is no doubt, however, that Motas experimented with *R. bursa* for he has sent me some of his specimens, and what is more, his observations on the biology of the tick, as far as they go, have been largely confirmed by me. It is clear that Dönitz's criticisms rendered it necessary to make a more detailed study of the subject.]

Throughout the following experiments, *R. bursa* was raised upon the shorn scrotum of a ram, or the ear of a calf, the scrotum or ear being enclosed in a bag which was opened daily for inspection; the engorged ticks which had abandoned the host, were collected and enumerated.

The time R. bursa *remains upon the host.*

Larva-nymph. (First generation.)

Larvae which emerged on 5. IX. 1911 from eggs laid by a ♀ received from Algeria, were placed on a *ram* 44–48 days after ecdysis, *i.e.* on three alternate days: 19–21–23. X. 1911. The 19th of October is reckoned as Day 1 in the following table. The ram was maintained at an average temperature of 9° C.

Date	Day	No. of gorged nymphs which dropped off host on successive days	Remarks
7. XI. 1911	20	1	Larvae are fully gorged about
	21	69	the 8th day; the nymphs
	22	312	emerge about the 12th day,
	23	477	and, reattaching themselves
	24	476	*in situ* upon the host, they
	25	414	proceed to suck blood and
	26	156	mostly drop off gorged on
	27	32	about the 22nd day.
	28	32	
	29	103	
	30	15	
	32	18	
	33	20	
	34	3	
	35	6	
	36	4	
	38	6	
27. XI. 1911	39	8	
		2152	

From this table it will be seen that a gorged nymph dropped off on the 20th day but that considerable numbers began to fall off only on the 22nd day; those abandoning the host in large numbers on the 24–26th day, are largely attributable to larvae placed on the ram on 21. and 23. x. 1911, *i.e.* 2–4 days later than the first batch. 22 days can therefore be accepted as the period of parasitism for the great majority. Assuming that the last ticks to drop off were those placed on the ram on 23. x. 1911, then the maximum period of parasitism may be reckoned at 36 days (not 39 days, as appears from the table).

(Second generation.)

Larvae (progeny of ♀ No. 2 raised in Cambridge) which emerged 1. VII. 1912 were placed on a ram on 7. x. 1912, 98 days having elapsed since they emerged. The ram was maintained at an average temperature of 8·5° C.

Date	Day	No. of gorged nymphs which dropped off host on successive days
26. x. 1912	19	2
	20–21	3
	22	27
	23	43
	24	9
	25	26
	26	34
	27	73
	28	32
	29	120
	30	40
	31	8
	32	50
	33	20
	34	86
	35	30
	36	193
	37	80
	38	30
	39	16
	40	60
	41–42	55
	43	30
	44	175
	45	90
	46	11
	47	8
	48	9
	49	170
26. xi. 1912	50	9
		Total 1539

The great irregularities observed in the supposed period of parasitism in this experiment must be attributed to experimental error due to the unfed ticks lying in the folds of the bag or only proceeding to feed upon the host after they had wandered about for an undetermined period. I have drawn attention to this source of error in the introduction to Part I (pp. 72–73). The minimum periods are always most trustworthy because of this source of error. The first gorged nymphs abandoned the host on the 19th day, larger numbers only after the 22nd day, so that bearing the source of error in mind, this record agrees with the previous one.

Adults (♀).

The ticks used for these observations began to emerge on 19. II. 1912 from the nymphal skin; they had therefore fasted for 64–170 days (at 19–21° C.) before they were applied to the host. Between 23. IV. and 7. VIII. 1912 equal numbers of ♂s and ♀s, 5–20 pairs at a time, were placed upon the host (calf or ram) at stated intervals. The temperature at which the hosts were maintained was not recorded, the animals were housed in unheated stalls.

Neither the temperature at which the host was maintained nor the length of time the ticks fasted appears to have exerted any appreciable effect upon the period of parasitism. The observations are, however, too few to permit of final conclusions.

Females.

Host	Date when put on host	No. of gorged ♀s collected on successive days	♀s had previously starved for	Remarks
Calf	23. IV. 1912	1 on day 11	64	[Motas states that fertilized ♀s feed for 7–8 days.]
		1 „ 12		
Calf	5. V.	3 on day 8	76	
Calf	7. V.	7 on day 7	78	
Calf	10. V.	1 on day 4	81	
		2 „ 5		
Calf	12. V.	2 on day 4	83	
		2 „ 5		
		1 „ 6		
Calf	12. VII.	1 on day 7	144	
		1 „ 11		
Ram	24. VII.	2 on day 7	156	
		8 „ 8		
		2 „ 9		
		1 „ 10		
Ram	7. VIII.	1 on day 7	170	
		1 „ 8		
		1 „ 9		
	Total	38 ♀		

Therefore 12 ♀s fed 8 days
5 „ 7 „
4 „ 5 „
3 „ 9 „
3 „ 4 „
2 „ 11 „
3 „ 6, 10 and 12 days respectively.

Males persist upon the host for an undetermined period after the females have dropped off gorged.

The time required by R. bursa *for metamorphosis.*

Egg to Larva.

No. of Lot	Eggs laid on	Larvae emerged after	Eggs maintained at average temp. of
1st gen.	16. VII. 1911	51 days	ca. 20° C.
2nd gen. Progeny of ♀ No.			
2	15. V. 1912	47	24° C.
3	21 V.	44	,,
4	22. V.	43	,,
5	21. V.	45	,,
6	23. V.	43	,,
8	25. V.	43	,,
10	24. V.	44	,,
11	27. V.	46	,,
12	26. V.	45	,,
14	26. V.	46	,,
15	29. V.	61	20·5° C.
16	27. V.	58	,,
17	13. VIII.	72	18·2 C.
18	11. VIII.	67	,,
19	11. VIII.	75	,,
20	10. VIII.	76	,,
21	10. VIII.	73	,,
22	11. VIII.	75	,,
23	9 VIII.	72	,,
24	10. VIII.	69	,,
25	10. VIII.	74	,,
26	10. VIII.	71	,,
28	14. VIII.	74	,,
29	9. VIII.	68	,,

The effect of temperature is clearly seen from this table for at

24° C. eggs hatched after 43–47 days
20° C. ,, ,, 50–58–61 days
18° C. ,, ,, 67–76 days.

Larva to Nymph. Metamorphosis, upon the host, takes place in 4 or more days.

Nymph to Adult.

No. of Lot	Host	Date on which gorged nymphs dropped off host	Adults emerged after	Ticks maintained at
1st gen.	Ram	9–12. XI. 1911	ca. 103 days	ca. 19° C.
2nd gen.	Ram	23–25. II. 1914	12–14 days	30° C.

Observations relating to oviposition of R. bursa.

Fertilized ♀s.

No. of Lot 1st gen.	Date when ♀ dropped from host	Oviposition began after	Oviposition lasted	Days ♀ survived after oviposition ceased	No. of eggs laid per ♀	♀ maintained at ca.	Remarks
♀2	4. v. 1912	11 days	33 days	3 days	—	24° C.	Females
3	13. „	8	35	7	—	„	1 and 9
4	„ „	9	43	2	—	„	died
5	„ „	8	35	3	—	„	without
6	14. „	9	45	24	—	„	laying
7	15. „	17	—	—	—	„	eggs.
8	„ „	10	36	4	—	„	
10	16. „	8	24	2	—	„	
11	„ „	11	34	12	—	„	
12	„ „	10	38	4	—	„	
13	„ „	13	—	—	—	„	
14	„ „	10	35	1	—	„	
15	19. „	10	33	26	6306	20° C.	
16	„ „	8	40	24	6276	„	
17	31. VII.	13	44	40	4959	18° C.	
18	„ „	11	46	40	6470	„	
19	„ „	11	44	—	5736	„	
20	„ „	10	48	23	6860	„	
21	„ „	10	47	17	6888	„	
22	„ „	11	45	32	6206	„	
23	„ „	9	46	44	6099	„	
24	„ „	10	46	28	6612	„	
25	„ „	10	48	33	—	„	
26	„ „	10	46	40	—	„	
27	„ „	11	43	9	—	„	
28	„ „	14	31	5	—	„	
29	„ „	9	29	1	—	„	

The duration of oviposition is not markedly influenced by variations of temperature within the limits 18–24° C.; a glance down the fourth column of the table shows, however, that at 18–20° C. the process is usually somewhat prolonged as compared to what takes place at 24° C.; shorter pre-oviposition periods also tend to occur at 24° C. than at 18–20° C. Within this range of temperature then, the pre-oviposition period lasts 8–17 days, the oviposition period 24–48 days.

Regarding *artificially induced parthenogenesis* in *R. bursa* see the paper which follows (p. 457).

Longevity of R. bursa *when unfed.*

Larvae. The ticks were maintained in corked tubes placed in semi-darkness in a cupboard at room temperature in the Quick Laboratory.

Progeny of single ♀s Nos.	Date when larvae emerged	Number of days larvae lived unfed
3	4. VII. 1912	352 days
4	4. VII.	330
5	5. VII.	343
6	5. VII.	358
8	7. VII.	363
10	7. VII.	349
11	11. VII.	337
12	10. VII.	360
14	12. VII.	322
15	26. IX.	276
16	27. IX.	268
17	24. X.	225
18	17. X.	232
19	26. X.	196
20	26. X.	182
21	23. X.	228
22	26. X.	222
23	21. X.	240
24	19. X.	173
25	24. X.	182
26	21. X.	270
27	24. X.	267
28	29. X.	233
29	19. X.	243

These data appear somewhat misleading, for they relate to the last signs of life exhibited by a very few survivors amongst roundly 5000 to 7000 larvae composing the progeny of 24 separate females. Even in the broods which survived for nearly a year the majority of the larvae usually ceased to be really active after about 200 days. Nevertheless the progeny of ♀ No. 20 were successfully raised after a starvation period of 182 days.

Nymphs. The longevity of the nymphs remains to be determined.

Adults.

Date of emergence	Examined after	Remarks
19. II. 1912	343 days and found active. 641 days and found all dead	1st generation. The lot comprised 1817 adults (824 ♂, 993 ♀).
7. I. 1913	364 days found all dead	2nd generation.
23. II. 1914	279 days and found roundly ¼ of the ♂s and ⅓ of the ♀s dead.	3rd generation. Out of 3463 gorged nymphs, there emerged 3363 adults, 100 nymphs having failed to undergo metamorphosis. The adults comprised a total of 1696 ♂ and 1667 ♀ of which 460 ♂ and 565 ♀ were dead.

Summary.

Rhipicephalus bursa requires two hosts upon which to feed (*a*) in the larval and nymphal stages and (*b*) as an adult. The tick is, partly for this reason, one of the easiest to rear. We have not attempted to rear it on other hosts than sheep and cattle. The larvae and adults feed readily a few days after they emerge, and after a fast of six months or more. *The length of time the tick remains upon the host* varies according to its seat of attachment and its consequent access to a supply of blood; under the most favourable conditions the *larvae* are fully gorged in about 8 days; they undergo metamorphosis whilst still attached to the host and the nymphs emerge about the 12th day. The nymphs, without altering their position upon the host, reattach themselves and proceed to feed, dropping off the host about 10 days later. The period of parasitism, reckoned from the time the larvae begin to feed until the replete nymphs abandon the host, lasts 19–20 days (minimum), in most cases 22–23 days, no doubt it may last longer if conditions are unfavourable. *Females* feed for 4–12 days (mostly 8 days) upon the host. *Males* remain attached for an indefinite period after the replete and fecundated females have dropped to the ground. When both sexes, or females alone, are placed upon the host, they attach themselves readily. In the absence of males the females feed very slowly, remaining attached for 15–91 days and never growing as replete as those which have been fecundated[1]. *Copulation* takes place upon the host. Whereas Motas states that the *proportion of the sexes* to each other is barely 1 ♂ to 3 ♀, we find, as the result of our extensive rearing experiments, that no such disproportion exists: the adults of the 1st generation raised in the laboratory numbered 1817 of which 824 were ♂ and 993 ♀; the adults of the 3rd generation numbered 3363 of which 1696 were ♂ and 1667 ♀; the sexes are therefore represented by nearly equal numbers. *Metamorphosis* from egg to larva lasts 43–47 days at 24° C., 67–76 days at 18° C.; from larva to nymph (upon the host) 4 or more days; from nymph to adult 12–14 days at 30° C., about 103 days at 19° C. The loss of life during metamorphosis from nymph to adult appears to be slight, thus of 3463 nymphs which had gorged themselves only 100 failed to reach maturity. *Oviposition*[1] commences 8–17 days (usually 8–11 days) after the gorged and fecundated female has abandoned the host and (when the ticks are maintained at ca. 18–24° C.)

[1] See the paper which follows (p. 457).

the process lasts 24–48 days (usually 31–48 days) and the female survives 1–44 days after oviposition has ceased. Counts of the number of eggs laid per female showed a range of roundly 4960–6900. *Longevity:* larvae were successfully raised after starving for 182 days, others, out of 24 lots observed, survived up to 363 days; the longevity of nymphs was not recorded; some adults survived up to 640 days, in one case, after 279 days' fasting, roundly a fourth of the males and a third of the females were found to have died out of a lot of 3363 adults. As both sexes in the lot were almost equally represented, this indicates that the males are perhaps longer-lived than the females. Adults after fasting 323 days and over have fed on a ram and are now yielding eggs (4th generation). Judging from our protocols the life-cycle under favourable conditions could scarcely be completed in less than about 110 days.

The part played by *R. bursa* in the transmission of ovine piroplasmosis is referred to on p. 439.

RHIPICEPHALUS SANGUINEUS.

The ticks to which the following protocols relate, were derived from two sources: (*a*) N. 237, were received 29. VIII. 1906, from Cairo, Egypt, through the courtesy of Professor Heinrich Bitter; the consignment comprised unfed adults and eggs from which larvae subsequently emerged. (*b*) N. 1932, adults, received 27. x. 1912, from the Central Research Institute, Kasauli, Punjab, India, the ticks having been forwarded by Captain C. D. Mackay to Major Christophers, I.M.S., whilst the latter was working in the Quick Laboratory.

[The only information we possess regarding the biology of this tick is contained in the publications of Christophers (1907 *a*, p. 4; 1907 *b*, pp. 40–43) and Patton and Cragg (1913, p. 642). Whilst the information supplied is meagre, it establishes certain essential points in the life-history. I shall quote the papers by Christophers by the numbers [1], [2] and the work of Patton and Cragg by the number [3] in the following two paragraphs so as not to overload the text with references which would interfere with their perusal. The details these authors give are cited *in extenso*, but I have arranged the data in accordance with the order adopted throughout this paper. The writers mentioned, are, also for brevity's sake, cited as "Authors" in the column headed "Remarks" in my protocols. As far as can be gathered the Authors used only dogs for the observations they record below, though they state that the jackal is a suitable host; they do not mention the temperature at

which the observations were made, which is to be regretted. Owing to the numerous data which were lacking I concluded that it was desirable to raise the species anew. The foregoing authors report as follows:

R. sanguineus is a three-host tick[2], [3]. The *larvae*, which are ready to feed 2–3 days after ecdysis[3], remain 3–4[1], [2] or about 5–8 days upon the host[3]; *nymphs* remain attached for 5[1] or 5–7 days[3]; *adults* (♀s being meant no doubt) remain upon the host for a few days to a week or more[2], or 8–10 days[3]. The ♂s stay upon the host after the ♀s have dropped off, they readily detach themselves from a dead dog and again attack a living animal[1]. The part of the host's body which is infested by the various stages varies somewhat: thus the larvae are stated to attach themselves anywhere, mostly, however, in hairy places where they are not easily found; nymphs are found on the body, including places where the skin is bare; adults occur especially inside the lobe of the ear, but also on the paws, along the back of the neck, although they are occasionally found in any position[2]. *Copulation* evidently takes place upon the host[2]. The period of *metamorphosis* from egg to larva is 7–10 days[3] or 3–4 weeks[1]; from larva to nymph it lasts 8–9[1] or 9–10 days[2]; from nymph to adults it lasts 15 days[1] or thereabouts[2]. *Oviposition* begins 3[1] or 2–4 days[3] after the gorged ♀ has abandoned the host and the process lasts 8 or more days[1], 4–7 days[2] or is completed in a week[3]. The replete ♀ measures 6–8 mm. in length, and, after abandoning the host, she tends to creep upward, in this way she may climb to a height of 15 feet above the ground upon the wall of a kennel. She hides herself in cracks, her body becoming flattened and it is difficult to draw the creature out of her retreat; in this position she lays "some thousands" of eggs[2].

Christophers[2] demonstrated by experiment that nymphs and adults descended from females infected with *Piroplasma canis*, and also adults emerging from nymphs which had fed on dogs suffering from piroplasmosis, were capable of producing this disease in other dogs upon which they were placed.]

[1] Christophers, 1907 a, p. 4.
[2] Christophers, 1907 b, pp. 40–43.
[3] Patton and Cragg, 1913, p. 642.

The following protocols relate to my raising experiments conducted in Cambridge

The time Rhipicephalus sanguineus *remains upon the host.*

Larvae.

No. of Lot (Progeny of separate ♀s)	Host	Date when put on host	No. of gorged larvae collected on successive days	Host maintained at average temp. of	Remarks
N. 237	Rabbit	18. x. 1906	— on day 4	14° C.	[Larvae feed
N. 1932 ♀ 6	Dog	12. iv. 1913	194 on day 3	6·5° C.	for 3–8 days,
			845 „ 4		according to
			131 „ 5		authors.]
			18 „ 6		
			4 „ 7		
N. 1932 ♀ 2	Dog	22. iv. 1913	352 on day 3	13° C.	
			236 „ 4		
			23 „ 5		
			2 „ 6		
N. 1932 ♀ 7	Dog	29. iv. 1913	16 on day 4	12° C.	
			98 „ 5		
			162 „ 6		
			111 „ 7		
			20 „ 8		
N. 1932 ♀ 1	Dog	24. v. 1913	7 on day 3	20° C.	
			43 „ 4		
			2 „ 5		
N. 1932 ♀ 3	Dog	2. vi. 1913	120 on day 3	19° C.	
			91 „ 4		
			3 „ 5		
			13 „ 6		
			11 „ 7		

The time Rhipicephalus sanguineus *remains upon the host.*

Nymphs.

No. of Lot	Host	Date when put on host	No. of gorged nymphs collected on successive days	Host maintained at average temp. of	Remarks
N. 237	Hedgehog	26. II. 1907	5 on day 10	11° C.	[Nymphs feed for 5–7 days, according to authors.]
			10 „ 11		
			8 „ 12–13		
			2 „ 14		
			1 „ 15		
			5 „ 16		
			1 „ 17		
N. 1932 progeny of ♀ 6	Dog	2. V. 1913	7 on day 3	12° C.	Nymphs placed on dog 10 days after they emerged.
			322 „ 4		
			69 „ 5		
			69 „ 6		
			68 „ 7		
			118 „ 8		
			35 „ 9		
			3 „ 10		
N. 1932 progeny of ♀ 2	Dog	4. VI. 1913	1 on day 3	18° C.	Nymphs placed on dog 33 days after they emerged.
			5 „ 4		
			69 „ 5		
			28 „ 6		
			5 „ 7		
			7 „ 8		
			16 „ 9		
			21 „ 10		
			11 „ 11		
N. 1932 2nd generation descended from ♀ 6	Jackal	24. XI. 1913	32 on day 3	8° C.	Nymphs placed on jackal 11 days after they emerged.
			344 „ 4		
			426 „ 5		
			25 „ 6		
			4 „ 7		

Adults (*Females*).

No. of Lot	Host	Date when put on host	No. of gorged ♀s collected on successive days	Host maintained at average temp. of	Remarks
N. 237	Dog	17. II. 1906	1 on day 15	ca. 12° C.	These 2 ♀s may have been feeble.
N. 237	Dog	17. IV. 1906	1 on day 21	ca. 16° C.	
N. 1932	Dog	14. II. 1913	13 on day 7	ca. 1·5° C.	80 ♀ and 69 ♂ were put on the dog simultaneously; only 27 ♀s were recovered gorged.
			12 „ 8		
			2 „ 9		
			—		
			27 ♀		
N. 1932 2nd generation	Jackal	8. I. 1914	16 on day 8	under 5° C.	30 ♀ and 34 ♂ put on dog simultaneously; only 3 ♀s were lost. The ticks had emerged 202 days before they were put on the jackal. [♀s feed for less than 7 or more than 10 days, according to authors.]
			8 „ 9		
			—		
			24 ♀		

The time required by R. sanguineus *for metamorphosis.*

Egg to Larva.

No. of Lot	Eggs laid on	Larvae emerged after	Eggs maintained at	Remarks
N. 237	29. III. 1906	75 days	ca. 12° C.	[Metamorphosis takes 7–28 days, according to authors.]
N. 1932 Progeny of				
♀ 1	24. II. 1913	18 days	30° C.	
2	„	18	„	
3	„	18	„	
4	„	17	„	
5	25. II. 1913	16	„	
6	„	16	„	
7	„	16	„	
8	24. II. 1913	18	„	
9	25. II. 1913	17	„	
10	„	17	„	
11	„	17	„	
12	„	17	„	
13	„	17	„	
14	„	19	„	
15	„	19	„	
16	„	19	„	
17	„	18	„	
18	„	17	„	
19	„	19	„	
20	„	17	„	
21	„	19	„	
22	„	19	„	
23	26. II. 1913	18	„	
24	27. „	17	„	
25	28. „	22	„	
26	27. „	18	„	
27	„	19	„	
N. 1932 2nd generation descended from ♀ 6. Progeny of 16 ♀s mixed.	21. I. 1914	17	„	

Larva to Nymph.

No. of Lot	Host	Date on which gorged larvae dropped off host	Nymphs emerged after	Ticks maintained at	Remarks
N. 237	Rabbit	22. X. 1906	9 days	?	[Metamorphosis takes 8–10 days, according to authors.]
N. 1932 Progeny of ♀ 2	Dog	25. IV 1913	6–7 days mostly	30° C.	
8	„	10. IV.	8 „ „	„	
6	„	15. IV.	6 „ „	„	
27	„	2. V.	6 „ „	„	
1	„	27. V.	5 „ „	„	
N. 1932 2nd generation descendants of ♀ 6. Progeny of several ♀s.	Jackal	6. XI.	7 „ „	„	
	„	26. VI. 1914	7 „ „	„	

Nymph to Adult.

No. of Lot	Host	Date on which gorged nymphs dropped off host	Adults emerged after	Ticks maintained at	Remarks
N. 1932					
Progeny of ♀ 2	Dog	7. VI. 1913	11 days mostly	30° C.	[Metamorphosis takes ca. 15 days, according to Christophers.]
♀ 6	Dog	5. V.	12 days mostly	„	
N. 1932 2nd generation descendants of ♀ 6. Progeny of several ♀s.	Jackal	27. XI.	11–12 days mostly	„	

Observations relating to oviposition in R. sanguineus.

Lot. No.	Host	Date when gorged ♀ dropped off host	Oviposition began after	Oviposition lasted	Days ♀ survived after oviposition ceased	No. of eggs laid per ♀	Temperature at which ♀ was maintained	Remarks
N. 237 *a*	Dog	4. III. 1906	25 days	—	—	—	ca. 12° C.	[Oviposition begins after 2–4 days, it lasts 4–8 or more days and "some thousands" of eggs are laid according to authors.]
N. 1932								
♀ 1	Dog	21. II. 1913	3 days	14 days	2 days	2720	30° C.	
2	„	„	3	12	3	1880	„	
3	„	„	3	13	2	2358	„	
4	„	„	3	12	3	2653	„	
5	„	„	4	12	2	2557	„	
6	„	„	4	14	19	2636	„	
7	„	„	4	11	5	2443	„	
8	„	„	3	15	6	3927	„	
9	„	„	4	13	1	1784	„	
10	„	„	4	13	3	2540	„	
11	„	„	4	13	1	1404	„	
12	„	„	4	14	6	3714	„	
13	„	„	4	12	1	—	„	
14	„	22. II. 1913	3	14	15	—	„	
15	„	„	3	14	6	—	„	
16	„	„	3	14	3	—	„	
17	„	„	3	12	1	—	„	
18	„	„	3	10	3	—	„	
19	„	„	3	13	1	—	„	
20	„	„	3	9	1	—	„	
21	„	„	3	12	2	—	„	
22	„	„	3	10	3	—	„	
23	„	„	4	14	3	—	„	
24	„	„	5	12	5	—	„	
25	„	„	6	13	6	—	„	
26	„	23. II. 1913	4	12	1	—	„	
27	„	„	4	12	19	—	„	

Longevity of unfed R. sanguineus.

Larvae.

Progeny of ♀ No.	Emerged from eggs on	Number of days larvae lived unfed	Larvae maintained in corked tubes at a temperature of
—	9. XII. 1913	97	ca. 12° C.
19	16. III.	153	ca. 15° C.
17	15. III.	161	—
11	14. III.	162	—
3	14. III.	174	—
4	13. III.	180	—
7	13. III.	187	—
26	17. III.	201	—
15, 21–24	16. III.	202	—
25	22. III.	203	—
10, 12	14. III.	204	—
5	13. III.	205	—
16	16. III.	222	—
13	14. III.	231	—
18	14. III	232	—
14	16. III.	244	—
20	14. III.	253	—

Nymphs.

	Nymphs emerged on	Number of days nymphs survived unfed	Nymphs maintained at
2nd gen. from ♀ 6	3. VII. 1914	2 out of 55 survived 97 days. (Of 58 gorged larvae only 3 failed to undergo metamorphosis to nymphs.)	22° C.

Adults.

Date of emergence	Examined on day	Maintained at room temperature, *i.e.* ca. 15° C.
10. XII. 1913	360	Out of a total of 132 adults there were 130 alive (59 ♂, 71 ♀) and 2 dead (2 ♂); 59 ⊙ had failed to undergo metamorphosis.
18 v. 1913	569	Out of a total of 575 adults there were 491 alive (170 ♂, 321 ♀) and 84 dead (54 ♂, 30 ♀), only 4 ⊙ had failed to undergo metamorphosis.

Summary.

Rhipicephalus sanguineus requires three hosts upon which to feed in the larval, nymphal and adult stages. The tick was readily reared by us under experimental conditions, the larvae being raised on dogs and rabbits, the nymphs on dogs, jackal and hedgehog, the adults on dogs and jackal. Under favourable conditions the larvae and nymphs are ready to feed 3–7 days after emergence, the adults in about a week. The length of time the ticks feed upon the host (dog or jackal) is 3–8 days (mostly 4 days) for the *larva*, 3–11 days (mostly 4 days) for the *nymph*. The character of the host appears to exert an influence, for we found that nymphs feed longer upon the hedgehog (10–17 days) than they did upon the other hosts mentioned. *Females* fed for 7–21 days (mostly 8 days); the ♂ persists upon the host for an undetermined period. The temperature at which the host is maintained appears to exert no influence upon the duration of the parasitic period of the immature stages, in the case of larvae the recorded temperatures ranged from 6·5° to 20° C., with nymphs it ranged from 8° to 18° C.; our observations on ♀s are too few to warrant any conclusions in this respect, but at 1·5° to 5° C., most of them abandoned the host on the 8th day which is about what has been observed to take place in a warm climate (India). *Copulation* takes place upon the host. The ♂s readily detach themselves and are often found wandering about, this behaviour, coupled with the fact that the ♀s are somewhat more numerous, permits of the conclusion that a ♂ may copulate with several ♀s. *Proportion of the sexes:* of 707 adults, descended from 2 ♀s, 285 were ♂ and 422 were ♀. The time required for *metamorphosis* from egg to larva is 17–19 days at 30° C., 75 days at 12° C.; from larva to nymph 5–8 days at 30° C.; from nymph to adult 11–12 days at 30° C. are required. The loss of life during metamorphosis is slight under favourable conditions, thus only 3 out of 58 larvae failed, after engorgement, to emerge as nymphs, and in one of two experiments only 4 out of 579 nymphs failed, after engorgement, to attain maturity. *Oviposition* commenced 3–6 days (mostly 3–4 days) after the ♀ had abandoned the host when the ticks were maintained at 30° C.; oviposition only began on the 25th day at 12° C.; the process lasted 9–15 days and the ♀s survived 1–19 days after the process was completed, having laid 1400 to 3900 eggs at 30° C. *Longevity* of some unfed ticks was very marked: one out of 20 lots of larvae survived for 253 days; on the other hand only 2 out of 55 nymphs survived for 97 days; adults in one case showed

great powers of fasting, for of 575 specimens only 84 had died by the 569th day, the survivors being still fairly lively when disturbed; the ♀s appear to be even hardier than the ♂s in this respect. *Variation:* Cunliffe (1914, *Parasitology*, VI. 372–378) working in my laboratory, has shown that small and large forms may readily be raised experimentally according as the nutrition of the immature stages has been more or less interfered with; he has figured the tick in all its stages.

Under the most favourable conditions, notably at a temperature of 30° C. during the period of metamorphosis, the life-cycle may be completed in 63 days; in nature the period may be indefinitely prolonged, depending upon temperature and the ability of the tick to find a host.

The part played by *R. sanguineus* in the transmission of canine piroplasmosis is referred to on p. 449.

ARTIFICIAL PARTHENOGENESIS IN TICKS.

By GEORGE H. F. NUTTALL, F.R.S.

(*From the Quick Laboratory, University of Cambridge.*)

The occurrence of parthenogenesis in ticks was referred to by me in a preliminary note (*Parasitology*, VI. pp. 139–140), wherein it was stated that I had observed it in *Rhipicephalus bursa* under experimental conditions. The following protocols relate to two attempts to raise the parthenogenetic offspring of several females. In both experiments the fed females and eggs were maintained at 30° C. until the females had died and the larvae had been given ample time (97–104 days) in which to emerge from the eggs. We failed, however, to raise the offspring beyond the larval stage.

Experiment 1.

Wherein 20 ♀s (1st generation) were placed upon a ram on 18. II. 1913. Only 1 ♀ was lost.

♀ No.	No. of days ♀ stayed on host	Date when ♀ dropped off host	No. of days before ovipos. began	No. of days ovi-position lasted	No. of days ♀ survived after ovipos.	No. of eggs laid per ♀	No. of days larvae emerged after	No. of larvae which emerged	No. of days sterile ♀s lived after dropping from host
1	25	15. III. 1913	5	17	33	1990	—	0	—
2	25	„	4	15	21	1680	18	2	—
3	30	20. III.	5	14	29	2160	12	10	—
4	52	11. IV.	—	—	—	0	—	—	3
5	54	13. IV.	9	10	14	1008	9	1	—
6	57	16. IV.	—	—	—	0	—	—	42
7	57	„	—	—	—	0	—	—	27
8	57	„	9	11	13	+s	—	0	—
9	57	„	8	9	9	+s	—	0	—
10	57	„	—	—	—	0	—	—	70
11	57	„	—	—	—	0	—	—	3
12	57	„	—	—	—	0	—	—	42
13	69	28. IV.	—	—	—	0	—	—	42
14	69	„	—	—	—	0	—	—	36
15	69	„	—	—	—	0	—	—	33
16	80	9. V.	—	—	—	0	—	—	36
17	84	13. V.	—	—	—	0	—	—	49
18	90	19. V.	—	—	—	0	—	—	38
19	91	20. V.	—	—	—	0	—	—	16

+s denotes that an undetermined number of eggs were laid which subsequently shrivelled up.

The 10 larvae, progeny of ♀ 3, were placed on a ram 31 days after they emerged, but none of them were recovered.

None of the 19 unfertilized ♀s became as fully gorged as did fertilized ♀s; their bodies were *all flattened* dorso-ventrally when they abandoned the host. In only 4 ♀s (Nos. 1, 2, 3, 6) did the length × width approach that of fertilized fully gorged ♀s. The measurements of 12 such ♀s are appended in the following table for comparison. The two sets of measurements do not show the main difference which is in the dorso-ventral direction.

Size attained by 19 unfertilized and by 12 fertilized ♀s, the latter chosen at random from a large stock:

Unfertilized ♀s.			Fertilized ♀s.		
♀ No.	Length × Breadth in mm.	No. of days ♀ fed on host	♀ No.	Length × breadth in mm.	No. of days ♀ fed on host
4	6·5 × 4·0	52 days	1	13·5 × 9·0	4–12 days
15	7·5 × 5	69 „	2	14·5 × 9	„
19	8·5 × 5	91 „	3	14·5 × 9·5	„
12, 14	9·5 × 6	57, 69 days	4	15·0 × 10	„
11, 17, 18	10 × 6	57, 84, 90 days	5	15·0 × 10	„
10, 13, 16	11 × 7	57, 69, 80 „	6	15·0 × 10	„
9	11·5 × 8	57 days, oviposited	7	15·0 × 11	„
7, 8	12 × 8	57, 57 days, one oviposited	8	15·5 × 10	„
5	12 × 8·5	54 days, oviposited	9	16·0 × 10	„
6	13 × 8	57 days	10	16·0 × 10	„
1, 3	13 × 9	25, 30 days, both oviposited	11	16·0 × 10	„
2	15 × 10	25 days, oviposited	12	17·0 × 11·5	„

It appears from the foregoing table, that unfertilized ♀s require to reach a certain size in respect to engorgement before they will in most cases lay any eggs. The length of stay on the host exerts no influence: the essential factor is the amount of blood which the tick has succeeded in imbibing.

Experiment 2.

Wherein 65 ♀s were placed on a ram on 8. VII. 1913; 15 ♀s were lost.

♀ No.	No. of days ♀ stayed on host.	Date when ♀ dropped off host.	No. of days before ovipos. began	No. of days oviposition lasted	No. of days ♀ survived after ovipos.	No. of eggs laid per ♀	No. of days larvae emerged after	No. of larvae which emerged	No. of days sterile ♀s lived after dropping from host
1	15	23. VII. 1913	3	14	1	4+30	29	64	—
2	34	11. VIII.	—	—	—	0	—	—	17
3	36	13. VIII.	5	14	1	+s	—	0	—
4	38	15. VIII.	4	13	2	2340	30	51	—
5	,,	,,	4	8	1	+s	—	0	—
6	,,	,,	8	14	8	+s	—	0	—
7	,,	,,	8	11	9	+s	—	0	—
8	,,	,,	8	9	9	+s	—	0	—
9	,,	,,	—	—	—	0	—	—	23
10	,,	,,	10	9	5	+s	—	0	—
11	,,	,,	5	10	27	676	29	90	—
12	,,	,,	—	—	—	0	—	—	60
13	,,	,,	10	12	4	+s	—	0	—
14	,,	,,	8	11	9	+s	—	0	—
15	,,	,,	—	—	—	0	—	—	85
16	,,	,,	12	5	22	+s	—	0	—
17	,,	,,	17	7	1	+s	—	0	—
18	,,	,,	6	9	24	+s	—	0	—
19	,,	,,	8	14	17	500s	—	0	—
20	,,	,,	8	14	17	+s	—	0	—
21	,,	,,	10	14	15	+s	—	0	—
22	,,	,,	10	7	10	+s	—	0	—
23	,,	,,	12	10	17	+s	—	0	—
24	,,	,,	12	5	7	100s	—	0	—
25	,,	,,	13	11	8	+s	—	0	—
26	,,	,,	13	5	15	12s	—	0	—
27	,,	,,	15	10	7	+s	—	0	—
28	,,	,,	19	8	7	+s	—	0	—
29	,,	,,	—	—	—	0	—	—	62
30	,,	,,	—	—	—	0	—	—	71
31	,,	,,	—	—	—	0	—	—	71
32	,,	,,	—	—	—	0	—	—	72
33	,,	,,	—	—	—	0	—	—	ca. 73
34	,,	,,	—	—	—	0	—	—	,,
35	,,	,,	—	—	—	0	—	—	,,
36	,,	,,	—	—	—	0	—	—	,,
37	,,	,,	—	—	—	0	—	—	,,
38	,,	,,	—	—	—	0	—	—	,,
39	,,	,,	—	—	—	0	—	—	,,
40	,,	,,	—	—	—	0	—	—	,,

The 's' in the seventh column denotes that the eggs shrivelled up; the + sign denotes that the eggs laid were not enumerated in these cases.

The 64 larvae, progeny of ♀ 1, were placed on a ram 23 days after they emerged, and the 90 larvae, progeny of ♀ 11, were placed on a ram 60 days after they emerged, but in neither case were any recovered gorged.

These observations show a marked contrast in the behaviour of fertilized and unfertilized females. Whereas all females placed with males upon the host dropped off gorged in 4–12 days (minimum and maximum periods), females in the absence of males remained upon the host for 15–38 days (Experiment 2) or 25–91 days (Experiment 1). Even after this long period of feeding, none of the unfertilized females became nearly as fully gorged as those which had been fertilized. Owing to the different temperature conditions under which the unfertilized and fertilized females were maintained (30° and 18–24° C. respectively), the duration of the pre-oviposition and oviposition periods cannot be compared. In the unfertilized females, all of which were maintained at 30° C., oviposition began after 4–9 days (Experiment 1) or 3–19 days (Experiment 2), the process lasting 9–17 days (Experiment 1) or 5–14 days (Experiment 2); the period of egg-laying might be equally shortened in fertilized females maintained at 30° C. Whereas 10 fertilized females laid roundly 4960–6890 eggs apiece, the 10 unfertilized females in our two experiments laid respectively 12, 100, 500, 676, 1008, 1680, 1990, 2160, 2340, and 4830 eggs apiece. Whilst only 2 out of 29 females to which males had had access died without ovipositing, of the unfertilized females there died 13 out of 19 (in Experiment 1) and 16 out of 40 (in Experiment 2) without ovipositing.

In my short note on parthenogenesis in ticks, to which reference has been made, it was stated that it was observed in *R. bursa*. I laboured under the impression that it was a normal though perhaps rare occurrence, but I am now convinced, as a result of repeating the experiment, that *the parthenogenesis observed was artificially induced by the manipulations accompanying the enumeration of the eggs.*

The method devised by me for enumerating the eggs laid by ticks is described in Part I (*Parasitology*, VI, pp. 73–74): "When enumerating by this method, we separate the eggs composing the mass by *immersing them in normal salt solution and rubbing them about gently* with the aid of a camel's hair brush"...etc. (not italicised in the original).

In the protocol of Experiment 1 it is stated that the eggs of four unfertilized ♀s were enumerated, and that the larvae emerged from three out of the four batches of eggs as follows:

Out of	1990	eggs there emerged 0 larvae
	1680	2
	2160	10
	1008	1
Totals	6838	13

Three ticks laid eggs which were not enumerated and from which no larvae emerged.

In the protocol of Experiment 2, it is stated that the eggs of six unfertilized ♀s were counted, and that larvae emerged from three out of six batches of eggs as follows:

Out of	4830	eggs there emerged 64 larvae
	2340	51
	676	90
	500	0
	100	0
	12	0
Totals	8458	205

Eighteen ticks laid eggs which were not enumerated and from which no larvae issued.

Therefore out of a total of 15,296 enumerated eggs there issued 218 larvae. To repeat, it was only a few of the eggs subjected to the manipulations consequent upon counting which yielded larvae, all the other eggs failed to hatch, although they were kept under observation up to the 97th–104th day after they were laid. Unfertilized eggs, in the great majority of cases, shrivelled up not long after they were laid, as is usually observed in such cases. Unfortunately failure attended the efforts which were made to raise the artificially produced offspring, but it is proposed to repeat shortly the experiment. I am not aware that artificial parthenogenesis has as yet been induced in Arachnoidea.

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